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## **Taxonomic Status of *Delias aestiva smithersi* Daniels, 2012 (Lepidoptera: Pieridae) comb. nov. from the Gulf Country of Northern Australia, with Description of the Female**

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**ABSTRACT.** The female of *Delias aestiva smithersi* Daniels, 2012 comb. nov. from northern Australia is illustrated and described for the first time. The subspecies is diagnosed and its taxonomic status clarified. Several unique character states concerning wing colour pattern elements of *D. aestiva smithersi*, together with evidence of the male genitalia, support the hypothesis that the subspecies belongs to *D. aestiva* Butler, 1897 and not to *D. mysis* (Fabricius, 1775). The taxon appears to have a restricted geographical range, being limited to the eastern Gulf of Carpentaria on the western side of Cape York Peninsula, Queensland (from Weipa to Karumba), where it occurs in mangrove habitats in coastal lowland areas. *Delias aestiva smithersi* and the nominate subspecies, *D. aestiva aestiva* Butler, 1897 from the “Top End”, Northern Territory, are allopatric and geographically separated by the Gulf of Carpentaria, suggesting that this biogeographical barrier (the Carpentarian Gap) has facilitated differentiation within the species, either through vicariance or dispersal.

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The *Delias mysis* (Fabricius, 1775) complex is restricted to mainland New Guinea and its adjacent islands, through the Aru Islands to northern and north-eastern Australia (Talbot, 1928–1937; Yagishita *et al.*, 1993). The complex currently includes five largely allopatric species (Davenport & van Mastrigt, 2009; Braby, 2012), namely: (1) *D. mysis*, with three subspecies (from Aru Islands, through south-eastern West Papua of mainland New Guinea to northeastern Australia); (2) *D. lara* (Boisduval, 1836), with five subspecies (throughout mainland New Guinea and its adjacent islands); (3) *D. doylei* Sanford & Bennett, 1955 (montane areas of the central cordillera of Papua New Guinea); (4) *D. euphemia* Grose-Smith, 1894 (Biak and Supiori); and (5) *D. aestiva* Butler, 1897 (coastal areas of the

‘Top End’ of northern Australia). The last mentioned species, *D. aestiva*, is perhaps the most remarkable member of the complex, and indeed the genus, because of its unusual, and apparently unique, occurrence in tropical mangrove habitats where the larvae specialise on foliage of the tree *Excoecaria* (Euphorbiaceae) (Braby, 2012) rather than the typical aerial/root hemiparasites in the Loranthaceae, Santalaceae and Viscaceae (Braby, 2006).

More recently, specimens belonging to the *D. mysis* complex have been discovered from western Cape York Peninsula in the Gulf of Carpentaria of northern Australia, including Weipa (Braby, 2000; Hancock & Monteith, 2004), Kowanyama and Karumba, Queensland (Daniels, 2012). Specimens (3♂♂) from the last two mentioned locations

were subsequently described by Daniels (2012) as a subspecies of *D. mysis*, under the name *D. mysis smithersi* Daniels, 2012, whereas material from Weipa (1♂, 1♀ in the private collection of T. A. Lambkin, Brisbane, 6♂♂ in the Australian National Insect Collection and 1♀ in the Queensland Museum) was placed under the nominate subspecies *D. mysis mysis* (Braby, 2000; Hancock & Monteith, 2004). The record from Weipa referred to by Hancock & Monteith (2004) was based on a female specimen collected in February 1976 by K. DeWitte.

The female of *D. mysis smithersi* has hitherto remained unknown. However, comparative study of two female specimens from Weipa, and critical re-examination of the type material of *D. mysis smithersi*, has revealed that the taxon *smithersi* has been erroneously placed in the species *D. mysis*, it most likely belongs to the species *D. aestiva*, and that the nine specimens (7♂♂, 2♀♀) from Weipa are in fact *D. aestiva smithersi* Daniels, 2012 comb. nov. rather than *D. mysis mysis* in which they are currently placed. The purpose of this paper therefore is to describe the female of *D. aestiva smithersi* and to diagnose and clarify the taxonomy of this subspecies from the nominate subspecies *D. aestiva aestiva* Butler, 1897 and the closely related *D. mysis mysis* (Fabricius, 1775) from Australia.

The following abbreviations refer to repositories where material has been examined:

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection, Canberra
MFBC	private collection of Michael F. Braby, Darwin
QM	Queensland Museum, Brisbane
TALC	private collection of Trevor A. Lambkin, Brisbane

### *Delias aestiva smithersi* comb. nov.

*Delias mysis smithersi* Daniels, 2012

Figs 1, 2

**Material examined.** Holotype ♂ “Karumba, Qld, 17°29'S, 140°50'E, 9 Oct. 2003, G.&A. Daniels” (AM); paratype ♂ “Karumba, Qld, 17°29'S, 140°50'E, 12 Dec. 2002, G. Daniels” (AM); paratype ♂ “Mitchell River [Kowanyama], Q., 26.x.[19]71”, “I.S.R. Munro”, “I.S.R. Munro Collection”, “genitalia 082, *Delias aestiva smithersi* ♂. Det. M.F. Braby” (AM); 1♀ labelled “Weipa, N. Qld., 3–5 Feb., 1976, [K. DeWitte]”, “QM Reg. No. T100951”, “AN31 000858” (QM); 1♂ labelled “Weipa Qld, 29 Aug 1994, [R.A. Eggleton]” (ANIC); 1♂, 1♀ labelled “Uningan Nature Reserve, Weipa, Q., 13.ix.1997, T.A. Lambkin” (TALC); 3♂♂ labelled similarly in ANIC; 2♂♂ labelled similarly but with date “18.ix.1997” (ANIC).

### Description

**Female** (Figs 1, 2). Forewing length 34.6 mm. Upperside pearly-white, with yellow markings on underside faintly visible; forewing with a black terminal band enclosing a series of three conspicuous cream subapical spots and three cream subterminal spots, the last between veins CuA<sub>1</sub> and CuA<sub>2</sub> very

obscure, terminal band extends narrowly along costa to base and may extend proximally along veins M<sub>3</sub>, CuA<sub>1</sub>, CuA<sub>2</sub> and 1A+2A; hindwing with a black terminal band, the inner edge of which may extend proximally along all main veins (M<sub>1</sub>–CuA<sub>2</sub>), red markings on underside faintly visible. Underside forewing similar to upperside except basal area broadly suffused with yellow, and the series of six subapical and subterminal spots larger, more conspicuous and of a different colour, the three spots between veins R<sub>1</sub> and M<sub>2</sub> yellow, while the three spots between veins M<sub>2</sub> and CuA<sub>2</sub> white; hindwing ground colour white, with base and dorsum broadly suffused with yellow, and a black terminal band enclosing a bright red narrower subterminal band, which extends from costa (above vein Rs) to dorsum (below vein 1A+2A).

**Diagnosis.** Braby (2012) listed 10 unique character states of the adult wing colour pattern elements and an additional eight morphological characters of the male genitalia by which *D. aestiva aestiva* is distinguished from *D. mysis mysis*. Daniels (2012) provided a number of characters (6 wing colour pattern elements) in which *D. aestiva smithersi* (originally placed in synonymy with *D. mysis*) is distinguished from *D. mysis mysis* and *D. aestiva aestiva*. However, taxonomic reappraisal of the status of the species-group name *smithersi* and the discovery of the female sex of this taxon, has necessitated a review of the features that distinguish *D. aestiva* and *D. mysis*, and the two subspecies of *D. aestiva*, because some of the characters were found to be non-applicable while others were overlooked.

A revised list of characters, and their states, that separate *D. aestiva* from *D. mysis* are tabulated in Table 1. A total of 10 diagnostic characters were found that distinguish the two species. *Delias aestiva smithersi* possesses all of these characters, the states of which are listed under *D. aestiva* in Table 1.

The males of *D. aestiva smithersi* may be distinguished from those of *D. aestiva aestiva* by the following four characters: (a) the apex of the forewing is more pointed; (b) the subapical spots on the upper- and underside of the forewing are proportionally larger; (c) the black terminal band on the upperside of the hindwing is narrower; in *D. aestiva aestiva* the band is particularly broad, being approximately twice the width of *D. aestiva smithersi*; and (d) the black terminal band on the underside of the hindwing is narrower, with the inner margin almost confluent with the red subterminal band; in *D. aestiva aestiva* the band is broader, with the inner edge extending proximally well beyond the red subterminal band.

Examination and comparison of two females of *D. aestiva smithersi* with a large sample of *D. aestiva aestiva* females ( $n = 35$ , MFBC) revealed similar character differences to the males. For example, the black terminal band on the upperside of the hindwing in *D. aestiva smithersi* females is narrower (in one specimen the inner margin of this band extends proximally along the major veins, but not in the other specimen); in *D. aestiva aestiva* females the band is broader, with the inner extensions along the veins less pronounced. In the specimen illustrated (Fig. 2) the fourth and fifth spots in the series of six submarginal spots on the underside of the forewing (i.e. those in cells M<sub>3</sub> and CuA<sub>1</sub>) are white suffused yellow in *D. aestiva smithersi*, but in the other specimen they are white; in *D. aestiva aestiva* these spots are always white without the yellow suffusion. In *D. aestiva smithersi* females, the inner margin of the black





Figures 1–4. Female *Delias aestiva* from northern Australia: (1, 2) *D. aestiva smithersi* from western Cape York Peninsula, Queensland (Weipa) (QM), showing upper- and underside; and (3, 4) *D. aestiva aestiva* from the Top End, NT (Darwin) (MFBC) showing extent of variation in underside pattern, particularly the width of the red subterminal band on the hindwing. Scale bar = 20 mm.

terminal band on the underside of the hindwing, like the males, extends only narrowly beyond the red subterminal band. The red subterminal band on the underside of the hindwing appears to be slightly broader compared with *D. aestiva aestiva*; however, additional material is needed to assess this character. The width of the red subterminal band is variable in *D. aestiva aestiva*, and the accompanying plate shows the extremes of variation (Figs 3, 4). For example, the width of the red spot in cell  $M_3$  in this subspecies ranges from 1.0 mm to 2.3 mm (mean = 1.5 mm  $\pm$  0.26 s.d.,  $n = 35$ ) (Fig. 5). The width of this spot in both females of *D. aestiva smithersi* is 2.0 mm, which falls within the observed range of *D. aestiva aestiva* (Fig. 5). Further specimens are required to ascertain if they are significant differences in the sample means of this character between the two taxa.

**Male genitalia.** The genitalia of one of the paratype males are illustrated in Fig. 6. The specimen possesses features that place the taxon with *D. aestiva* rather than *D. mysis* (see Braby, 2012 for comparative illustrations). These features include the shape of the saccus, and the shape of the valva, which, in lateral view, is rounded and convex at its posterior

end (in *D. mysis*, the posterior end of the valva is distinctly pointed or protruded). The valva, in dorsal view, in *D. aestiva smithersi* and *D. aestiva aestiva* is broader in width and less tapered apically with shorter setae on its inner surface compared with *D. mysis mysis*. The uncus of the two species is similar in profile, with the apex divided into three lobes; however, in *D. aestiva smithersi* and *D. aestiva aestiva*, the uncus is slightly broader and shorter in length, and there are substantial differences at its point of attachment with the tegumen, which is also broader than that of *D. mysis mysis*. The phallus was missing in the specimen dissected and therefore not available for comparison. Dissection of several specimens of *D. aestiva aestiva* (in MFBC) revealed minor variation in the male genitalia, particularly the form of the valva, but there was insufficient material to assess the extent of intrasubspecific variation within *D. aestiva smithersi*.

**Distribution.** *Delias aestiva smithersi* occurs in the eastern Gulf of Carpentaria where it is known from three locations on the western side of Cape York Peninsula, from Weipa to Karumba, QLD (Fig. 7). All locations are situated in coastal lowland areas that support extensive stands of mangroves,

**Table 1.** Phenotypic character state differences in wing colour pattern elements between *Delias aestiva* and *D. mysis*. *FW* = forewing; *HW* = hindwing.

character	<i>Delias aestiva</i>	<i>Delias mysis</i>
(1) ♂, ♀ FW upperside black apical band	narrower in width; longer in extent in ♂, extending beyond vein CuA <sub>2</sub> , and with its inner edge more evenly rounded anteriorly	broader in width; shorter in extent in ♂, stopping at vein CuA <sub>2</sub> , and with its inner edge relatively straight
(2) ♂, ♀ FW underside black apical band	narrower in width; in ♀ the inner edge usually extends proximally along veins M <sub>3</sub> , CuA <sub>1</sub> and CuA <sub>2</sub>	broader in width; in ♀ the inner edge is approximately straight
(3) ♂, ♀ FW upperside subapical and subterminal spots	larger and more pronounced, with up to 5 or 6 spots	smaller and less pronounced (especially ♀), with up to 5 spots
(4) ♂, ♀ HW underside black terminal band	inner edge less strongly curved and pronounced between veins CuA <sub>1</sub> and 1A+2A	inner edge strongly curved and pronounced between veins CuA <sub>1</sub> and 1A+2A
(5) ♂, ♀ HW underside red subterminal band	narrower in width, especially between veins CuA <sub>1</sub> and 1A+2A; shorter in ♂, terminating at vein Rs	broader in width, especially between veins CuA <sub>1</sub> and 1A+2A; longer in ♂, terminating at vein Sc+R <sub>1</sub>
(6) ♂ HW underside yellow basal area	less extensive, rarely extending beyond vein CuA <sub>2</sub> and occupying less than half of discal cell	extensive, often extending beyond vein CuA <sub>2</sub> and occupying more than half of discal cell
(7) ♀ FW upperside basal area	white, without grey suffusion	white, with conspicuous grey suffusion
(8) ♀ FW underside subapical spots (3 spots between veins R <sub>1</sub> and M <sub>2</sub> )	yellow	white, only anterior spot near costa is sometimes yellow
(9) ♀ FW underside yellow basal area	extensive, occupying more than three-quarters of discal cell, as well as extending into areas well below cell	restricted to very base of discal cell
(10) ♀ HW underside yellow basal area	extensive, especially along costa where it may extend to end of vein Sc+R <sub>1</sub>	less extensive, especially along costa where it is restricted to basal area

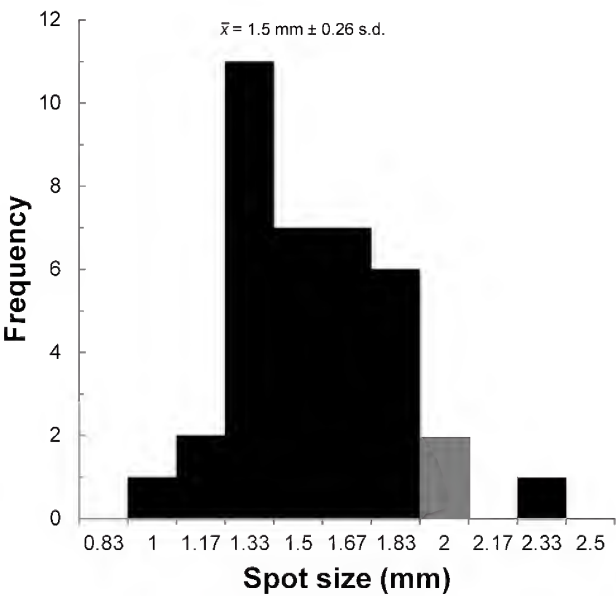


Figure 5. Frequency distribution of the size of the red subterminal band (width of red spot in cell M<sub>3</sub>) on the underside of the right hindwing of female *Delias aestiva aestiva* based on a sample ( $n = 35$ , MFBC) of specimens from Darwin, Northern Territory. Sample mean and standard deviation are indicated above graph. The grey bar indicates the size of the corresponding band in the two female specimens of *D. aestiva smithersi* examined.

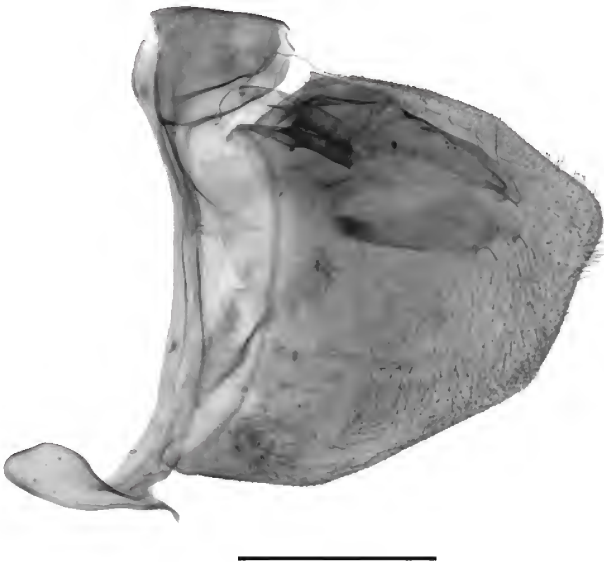


Figure 6. Male genitalia of *Delias aestiva smithersi* from Mitchell River, Queensland (AM); lateral view with left valva and phallus removed. Scale bar = 1.0 mm.



particularly in estuarine areas along banks of rivers and creeks. The geographical range is allopatric with *D. aestiva aestiva*, which is restricted to the northern coastal areas of the Top End of the Northern Territory on the western side of the Gulf of Carpentaria.

### Discussion

The ten unique character states of *Delias aestiva smithersi* listed in Table 1, together with evidence of the male genitalia, support the hypothesis that the taxon belongs to *D. aestiva* and not to *D. mysis*. There are at least four phenotypic characters (wing colour pattern and shape) that distinguish *D. aestiva smithersi* from *D. aestiva aestiva*, indicating that subspecific classification is the most plausible hypothesis for this butterfly (see criteria proposed by Braby *et al.*, 2012).

Adults of *D. aestiva smithersi* have been collected in the months of February, September, October and December; they have also been collected in August at Weipa (along the Hay River) by I. R. Johnson and S. J. Johnson (pers. comm.). Collectively, these temporal records suggest a relatively long flight period, possibly throughout much of the year. The males fly low to the ground, usually within or in close proximity to mangroves (G. Daniels & T. A. Lambkin, pers. comm.), behaviour that is typical of the nominate subspecies in the Top End (Braby, 2012). This flight behaviour contrasts markedly with that of *D. mysis* and other members of the *D. mysis* species group, which fly higher in the canopy and mid-canopy of tropical forest.

The larval food plant and biology are presently unknown, but on account of its distribution and known habitat, *D. aestiva smithersi* is likely to specialize on the mangrove *Excoecaria agallocha-ovalis* complex, which is the larval food plant of *D. aestiva aestiva* in the Northern Territory (Braby, 2012). This plant is common locally in the Gulf of Carpentaria, and on western Cape York Peninsula it extends as far north as Weipa (CHAH 2009), which coincides with the distribution of the butterfly.

Further work is needed to clarify the spatial and temporal distribution and ecology of the subspecies. The known geographical ranges of *D. aestiva smithersi* and *D. aestiva aestiva* indicate that the two subspecies are allopatric, being geographically separated by the Gulf of Carpentaria. This large body of seawater and the adjacent mainland consisting of dry clay plains to the south, often referred to as the Carpentarian Gap, has been hypothesized to comprise a biogeographical filter, functioning as a barrier for taxa with disjunct distributions in Cape York Peninsula and the Top End of the Australian monsoon tropics and a corridor for others (Bowman *et al.*, 2010). During the last interglacial maximum (c. 9 ka BP), the coastline of the Gulf was connected at its northern end via Lake Carpentaria (Williams, 2001); however, since the demise of Lake Carpentaria during the Quaternary with sea-level rise (Lake Carpentaria is now submerged by the Gulf of Carpentaria), populations of some species distributed to the east (Cape York Peninsula) and west (Top End-Kimberley) of the lake became geographically isolated. Thus, the Carpentarian Gap may be barrier that has facilitated subspecific differentiation within *D. aestiva*. Further work on the timing of this event using DNA-based dating methods in relation to the geological history of the region may help elucidate the historical mechanism (i.e. vicariance or dispersal) of divergence.

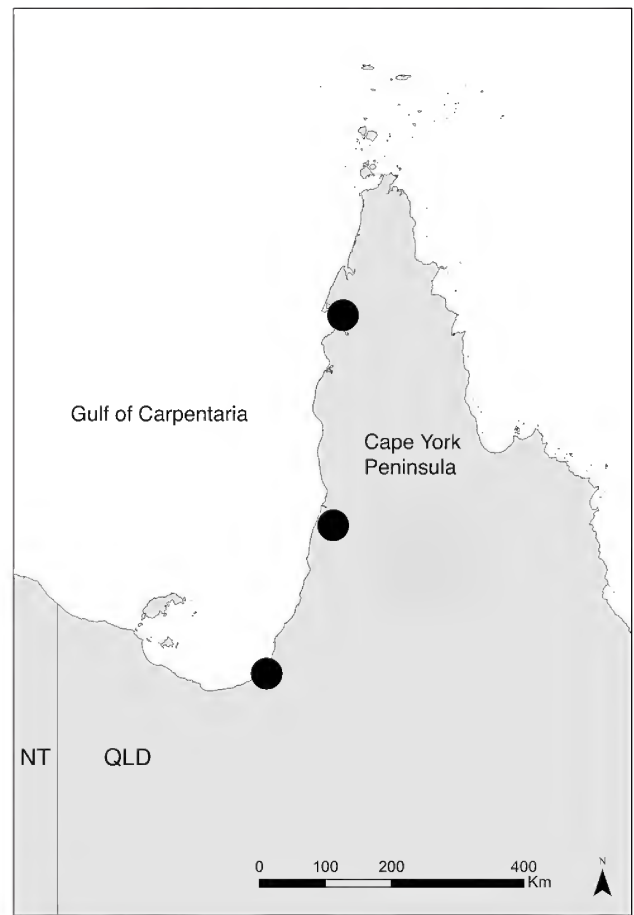


Figure 7. Spatial distribution of *Delias aestiva smithersi*, showing known locations on western Cape York Peninsula in the eastern Gulf of Carpentaria, Queensland, Australia.

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### References

- Bowman, D. M. J. S., G. Brown, M. F. Braby, J. Brown, L. Cook, M. D. Crisp, F. Ford, S. Haberle, J. M. Hughes, Y. Isagi, L. Joseph, J. McBride, G. Nelson, and P. Y. Ladiges. 2010. Biogeography of the monsoon tropics. *Journal of Biogeography* 37: 201–216. <http://dx.doi.org/10.1111/j.1365-2699.2009.02210.x>
- Braby, M. F. 2000. *Butterflies of Australia. Their Identification, Biology and Distribution*. Collingwood, Melbourne: CSIRO Publishing.
- Braby, M. F. 2006. Evolution of larval food plant associations in *Delias* Hübner butterflies (Lepidoptera: Pieridae). *Entomological Science* 9: 383–398. <http://dx.doi.org/10.1111/j.1479-8298.2006.00185.x>

- Braby, M. F. 2012. The taxonomy and ecology of *Delias aestiva* Butler, 1897 stat. rev. (Lepidoptera: Pieridae), a unique mangrove specialist of Euphorbiaceae. *Biological Journal of the Linnean Society* 107: 697–720.  
<http://dx.doi.org/10.1111/j.1095-8312.2012.01970.x>
- Braby, M. F., R. G. Eastwood, and N. Murray. 2012. The subspecies concept in butterflies: has its application in taxonomy and conservation biology outlived its usefulness? *Biological Journal of the Linnean Society* 106: 699–716.  
<http://dx.doi.org/10.1111/j.1095-8312.2012.01909.x>
- CHAH. 2009. Australia's Virtual Herbarium (AVH). Council of Heads of Australasian Herbaria Inc., Canberra.  
<http://www.chah.gov.au/avh/index.jsp>
- Daniels, G. 2012. A new subspecies of *Delias mysis* (Fabricius) (Lepidoptera: Pieridae) from the Gulf of Carpentaria, Queensland, Australia. *The Australian Entomologist* 39: 273–276.
- Davenport, C., and H. J. G. van Mastrigt. [2009]. Revision of *Delias mysis* (Fabricius, 1775) and closely related species (Lepidoptera: Pieridae). *Suara Serangga Papua* 3: 15–31 [dated 2008, but published 2009].
- Hancock, D. L., and G. B. Monteith. 2004. Some records of butterflies (Lepidoptera) from western Cape York Peninsula, Queensland. *The Australian Entomologist* 31: 21–24.
- Talbot, G. 1928–1937. *A Monograph of the Pierine Genus Delias. Parts I–VI*. London: British Museum (Natural History).
- Williams, M. A. J. 2001. Morphoclimatic maps at 18 ka, 9 ka, & 0 ka. In *Atlas of Billion-year earth history of Australia and neighbours in Gondwanaland*, ed. J. J. Veevers, pp. 45–48. Sydney: GEMOC Press.
- Yagishita, A., S. Nakano and S. Morita. 1993. *An Illustrated List of the Genus Delias Hübner of the World*. Tokyo: Khepera Publishers.

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## Review of the Australian Genus *Pentachaeta* (Diptera: Heleomyzidae), with Descriptions of Nine New Species

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**ABSTRACT.** The taxonomy of the forest-dwelling flies of the endemic Australian genus *Pentachaeta* McAlpine, 1985 (family Heleomyzidae or Heteromyzidae), is investigated, with particular reference to structure of the male genitalia. The number of described species is increased from one to ten. The following new species are described: *Pentachaeta edwardsi*, *P. bickeli*, *P. inserta*, *P. bassiana*, *P. skusei*, *P. gilliesi*, *P. impar*, *P. kirkspriggsi*, *P. pinguis*.

MCALPINE, DAVID K. 2014. Review of the Australian genus *Pentachaeta* (Diptera: Heleomyzidae), with descriptions of nine new species. *Records of the Australian Museum* 66(5): 247–264.

The genus *Pentachaeta* has been known to me for many years, as indicated by the collection dates on some of the material listed below, but only the type species, *P. physopus* McAlpine, 1985, has yet been described. It now appears that sufficient material is available to characterise most of the species, at least for male specimens, but the females of some species cannot be easily identified from morphological characters.

I have placed *Pentachaeta*, together with the little known Chilean genus *Dioche* McAlpine, in the tribe Pentachaetini of the subfamily Trixoscelidinae (McAlpine, 1985; 2007). This classification is based on slender morphological evidence and should be subjected to detailed molecular evidence, when suitable material is available.

The structure of the protandrium, hypandrium, and aedeagus of the male abdomen varies greatly among the tribes of Heleomyzidae, so that it may be taken to indicate a polyphyletic origin for the so-called family (see Griffiths, 1972). However, some more detailed species-level studies (e.g., in the Allophylopsini by McAlpine, 1967, and the Borboroidini by McAlpine, 2007) indicate that gross

divergence in characters of the male postabdomen often begins during or immediately following the speciation process, so that major structural differences can occur between quite closely related groups.

In listing material the following collectors' names are abbreviated to the initials: H. Anderson, D. J. Bickel, B. W. Bradfield, D. H. Colless, G. Daniels, B. J. Day, G. H. Hardy, G. A. Holloway, D. S. Kent, R. de Keyser, K. C. Khoo, R. Lossin, D. K. McAlpine, S. F. McEvey, E. F. Riek, C. N. Smithers, N. B. Tindale, M. S. Upton, J. C. Wiburd, G. A. Williams, and W. W. Wirth.

The following abbreviations refer to institutions holding collections:

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection, CSIRO, Canberra
MV	Museum Victoria, Melbourne
QM	Queensland Museum, Brisbane
SAM	South Australian Museum, Adelaide
USNM	National Museum of Natural History, Washington, D.C.



Figure 1. *Pentachaeta pinguis*, northern form, female (13 km N of Ravenshoe).

### *Pentachaeta* McAlpine

*Pentachaeta* McAlpine 1985: 212–213. Type species (original designation): *P. physopus* McAlpine.

For diagnostic description see McAlpine (1985). The genus is keyed among the Australian heleomyzid genera by McAlpine (1985: 204–206) and McAlpine (2007: 155–156). The general coloration is distinctive for the genus: thorax largely pale tawny-orange with narrow brown longitudinal stripe on region of humeral callus and notopleuron; wing with one continuous broad brown anterior stripe covering entire costal margin and separate brown mark surrounding discal (posterior or dm-cu) cross-vein (Fig. 1). These features, together with the following conditions of chaetotaxy make the genus easily recognisable among other Australian acalyptrate flies: single vibrissa strongly developed; postvertical bristles rather large, strongly convergent from bases; propleural (proepisternal) bristle large and isolated; mesopleuron (anepisternum) without setulae or bristles; dorsocentral bristles five large subequal pairs (Fig. 2). Size range is indicated by a wing-length of between 2.5 and 4.8 mm.

### Male postabdomen

Within the genus *Pentachaeta* there is fairly consistent structure of the postabdominal parts (with a few exceptional conditions in some species) and some contrast with the structure so far observed in other heleomyzid tribes. The incompletely known Neotropical genus *Dioche* shows some agreement with *Pentachaeta* in hypandrial structure. The structure of the protandrium (the male postabdominal segments immediately preceding the genital segment) has been described for *Dioche* and *Pentachaeta* by McAlpine (1985). Other male postabdominal structures are here considered in more detail, but I do not here follow the terminology previously used for *P. physopus* (McAlpine, 1985: 213, fig. 22).

The epandrium bears a pair of large surstyli, visibly articulated at the bases but usually not very freely so. In several species the inner basal surface of the surstylus has a group of stout setulae, and sometimes these are located on a basal prominence (e.g., Figs 5). The subepandrial cuticle is not markedly sclerotized except, in most species, for a distally setulose subepandrial process which arises on each side near the base of the surstylus. This is perhaps homologous with

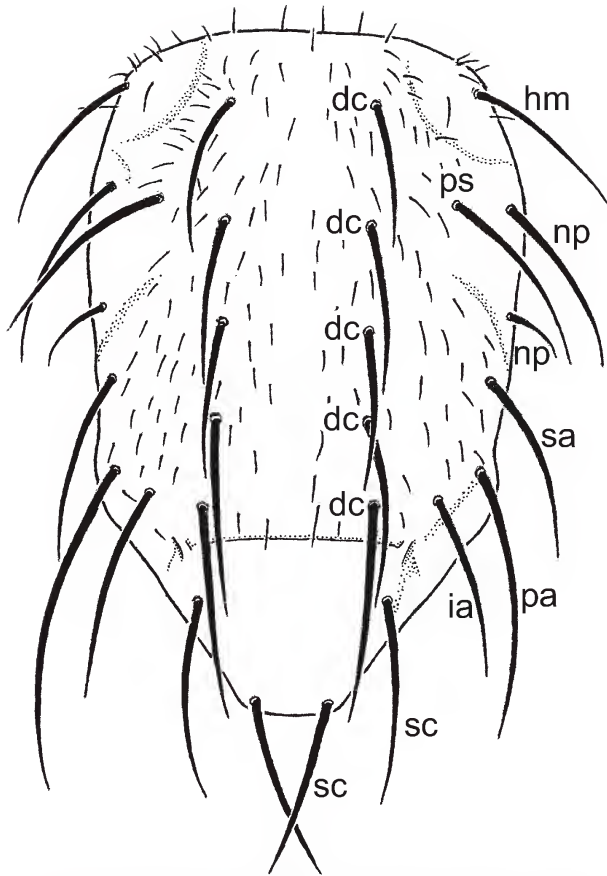


Figure 2. *Pentachaeta edwardsi*. Dorsal view of thorax, showing chaetotaxy. *dc*, dorsocentral bristles (five pairs); *hm*, humeral bristle; *ia*, intra-alar bristle; *np*, notopleural bristles; *pa*, postalar bristle; *ps*, presutural bristle; *sa*, supra-alar bristle; *sc*, scutellar bristles.

the “process of sternite 10” illustrated by Gill & Peterson (1987: figs 11,12) for a heleomyzine example, though differing in form. This structure was identified as “surstylus” by Gorodkov (1963: fig. 2b), who used the term “edita” for the processes usually termed surstylus or surstyle. It remains to be decided whether the subepandrial process in these heleomyzids is homologous with the anterior epandrial process occurring in some taxa of Helosciomyzidae and related sciomyzoid families (see McAlpine, 2012: fig. 14).

The hypandrium (Fig. 3), with its associated structures, including the aedeagus, is very distinctive for the genus. The fork plate (*Gabelplatte*) consists of a pair of longitudinal sclerites, connected to each other anteriorly, and each narrowly connected posteriorly to a lateral sclerite bearing the gonostylus (postgonite). The gonostylus varies in shape but always bears a few elongate distal macrotrichia and sometimes a tuberclose distal zone. The basiphallus consists anteriorly of a pair of longitudinal sclerites, joined together anteriorly where they are attached to the aedeagal apodeme and posteriorly where they support the base of the distiphallus and bulb. The cuticle of the region of sternite 9 is recessed to form a pouch of which the basiphallus, the fork plate and the aedeagal apodeme contribute to the otherwise membranous lining, and into which the bulb can be withdrawn. The bulb is partly irregularly sclerotized and shows some variation in structure. In *Pentachaeta impar* n. sp. (Fig. 36) the bulb possesses two broadly tubular structures with funnel-like openings. It is uncertain if these openings are functional gonopores, but in other species the gonopore

appears to be located on the distal part of the section here identified as the distiphallus. Posteriorly on each side the basiphallus has an elongate, minutely densely pubescent extension, which is connected to the posterior extremity of the hypandrium by a compact articulating sclerite.

The cerci are approximated but not basally fused, large, elongate, strongly setulose at least in part and often partly microtrichose (fine microtrichia not shown in my illustrations), projecting anteriorly from the elongate attachment to the ventral surface of the tip of abdomen. They are of variable but often highly specific form.

### Distribution

Eastern Australia—mainly higher rainfall areas from Atherton Tableland, Northern Queensland, to Tasmania, also westward to Adelaide district, South Australia. See map (Fig. 4).

The species of *Pentachaeta* live mainly in wet temperate to subtropical forests, one species (*P. gilliesi*) extending into drier areas. The immature stages are unknown. From what is known of the ecological associations, the genus is unlikely to have economic significance.

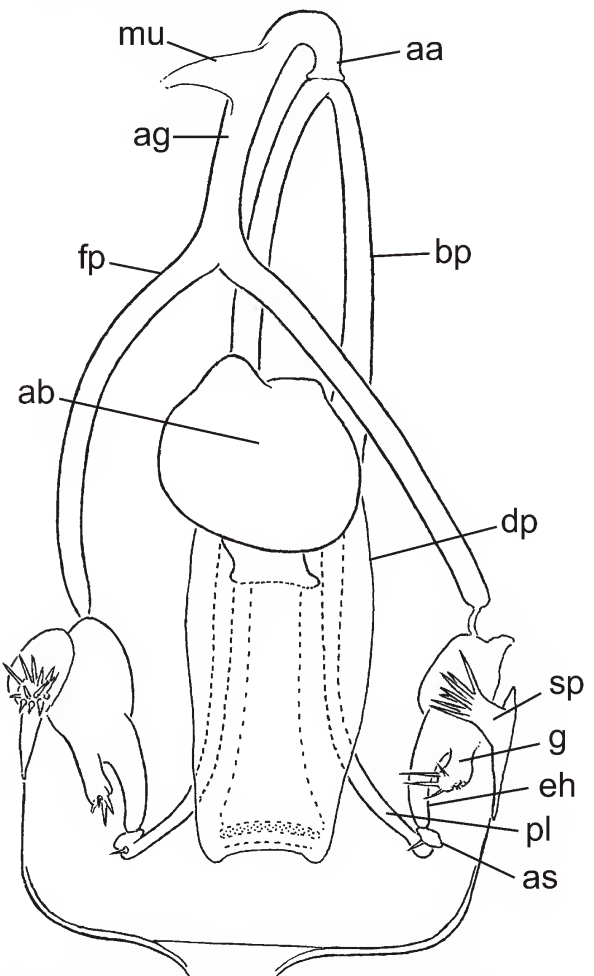


Figure 3. *Pentachaeta edwardsi*. Hypandrial structures, ventral view (diagrammatic). *aa*, aedeagal apodeme; *ab*, aedeagal bulb; *ag*, aedeagal guide (connecting aedeagal apodeme to hypandrium anteriorly); *as*, articulating sclerite; *dp*, distiphallus; *eh*, sclerotized extension of hypandrium; *fp*, fork plate of hypandrium; *g*, gonostylus; *mu*, probable muscle attachment; *pl*, posterolateral extension of basiphallus (partly densely pubescent); *sp*, subepandrial process (on subepandrial cuticle).



### Key to species of *Pentachaeta*

#### A. Males

- 1 Hind tibia (and sometimes other tibiae) swollen, nearly as stout as femur; fore tarsus variously coloured ..... 2
  - All tibiae relatively slender (as in females); fore tarsus entirely brown to blackish (except in *P. skusei*) ..... 6
- 2 Antenna black; palpus broadly tipped with black; genitalia as in Figs 40–42; habitat tropical Queensland ..... *pinguis* n. sp., part
  - Antenna yellowish to tawny (clean specimens); other characters various; habitat generally temperate Australia ..... 3
- 3 Upper margin of sternopleuron brownish (unfaded specimens); only hind tibia swollen, fore tibia slender as in female; surstylus (Fig. 34) with few very large setulae externally, internally densely microtrichose ..... *impar* n. sp.
  - Sternopleuron entirely tawny-yellow; both fore and hind tibiae swollen; surstylus with all setulae smaller ..... 4
- 4 Palpus broadly brown to blackish apically; fore tibia almost entirely brown; genitalia as in Figs 40–42 ..... *pinguis* n. sp., part
  - Palpus entirely tawny-yellow; tibiae and genitalia various ..... 5
- 5 Fore tarsus predominantly tawny-yellow; genitalia as in Figs 37–39 ..... *kirkspriggsi* n. sp.
  - Fore tarsus brown to black; genitalia as in Figs 43, 44 ..... *physopus* McAlpine
- 6 Fore tarsus in large part tawny-yellow; genitalia: cercus as in Figs 27, 28, with anteromedial, non-marginal setulose tubercle; surstylus shaped as in Fig. 26 ..... *skusei* n. sp.
  - Fore tarsus entirely brown to blackish; cercus without such setulose tubercle; surstylus otherwise ..... 7
- 7 Cercus not much broadened at base of anterior lobe, which is elongate, not tapering (Fig. 30); surstylus moderately broad (Fig. 31) ..... *gilliesi* n. sp.
  - Cercus very broad just before narrowing into anterior lobe; surstylus variable ..... 8
- 8 Surstylus much broadened just beyond mid length, then abruptly narrowed at twisted apex (Fig. 23); cercus as in Fig. 24 ..... *bassiana* n. sp.
  - Surstylus slender; cercus diverse ..... 9
- 9 Bulb of aedeagus with several invaginated conical tooth-like sclerites (Figs 21, 22); cercus as in Fig. 19 ..... *inserta* n. sp.
  - Bulb of aedeagus without such invaginated sclerites; anterior lobes of two cerci diverging (Figs 6, 13) ..... 10
- 10 Anterior lobes of two cerci widely divergent from their origins, each with small, sharp medial tooth at its origin (Fig. 13) ..... *bickeli* n. sp.
  - Anterior lobes of two cerci together forming V-shaped outline as they diverge, each without tooth at its origin (Fig. 6) ..... *edwardsi* n. sp.

#### B. Females [some not readily identifiable to species]

- 1 Antenna blackish; palpus broadly tipped with black; habitat tropical Queensland ..... *pinguis* n. sp., part
  - Antenna tawny-yellow, sometimes partly yellow-brown (clean specimens); palpus various; habitat mainly Australia S of 23°S ..... 2
- 2 Fore tibia entirely brown to blackish; palpus entirely yellow, not darkened apically ..... *physopus* McAlpine
  - Fore tibia largely tawny yellow; palpus variably coloured ..... 3

- |    |  |  |
|----|--|--|
| 3  | Fore tibia not darkened apically .....   | 4  |
| —  | Fore tibia with brown apex (often with separate anterior and posterior apical brown marks) ..... | 6  |
| 4  | Upper margin of sternopleuron suffused with brown .....  | <i>impar</i> n. sp.  |
| —  | Sternopleuron entirely tawny-yellow .....  | 5  |
| 5  | Palpus brown to blackish apically .....  | <i>pinguis</i> n. sp., part  |
| —  | Palpus entirely tawny yellow .....   | <i>kirkspriggsi</i> n. sp.   |
| 6* | Fore tarsus with segments 2–4 largely tawny yellow .....   | [probably] <i>skusei</i> n. sp.  |
| —  | Fore tarsus entirely brown .....   | [probably] <i>inserta</i> n. sp., <i>bickeli</i> n. sp.,<br><i>edwardsi</i> n. sp., <i>bassiana</i> n. sp., <i>gilliesi</i> n. sp. |

\* Hypothetical couplet as female of *P. skusei* is unknown. It is likely that tarsal coloration of females resembles that of conspecific males.

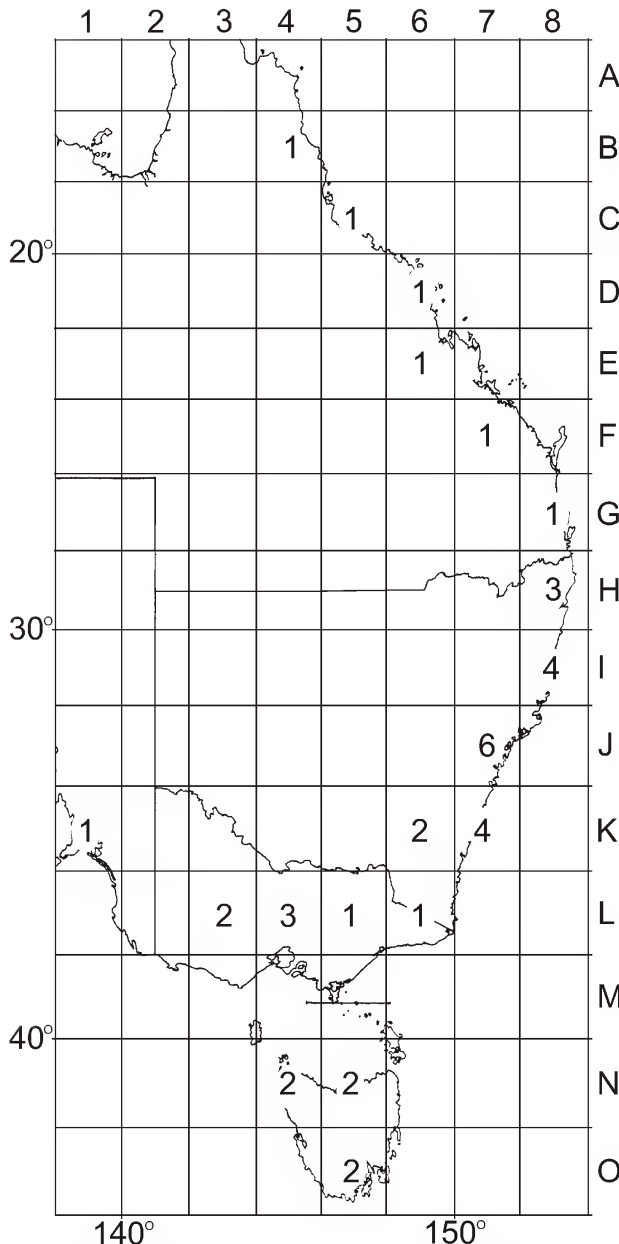


Figure 4. Reference map for distribution of *Pentachaeta* species in eastern Australia. Numbers in each rectangle (2° longitude by 2° latitude) are numbers of recorded species. Map references are given under Distribution for each species.

### *Pentachaeta edwardsi* n. sp.

Figs 2, 3, 5–10

**Type material.** Holotype ♂. New South Wales: Mooney Mooney Creek, W. of Gosford, c. 33°26'S 151°15'E, 20.xi.1975, D.K.M. (AM K310591). Glued to card point, postabdomen in genitalia tube on same pin. Paratypes. 28 ♂♂, same locality as holotype, Nov., Dec., Jan. 1975–1989, D.K.M., B.J.D. (AM, ANIC, USNM).

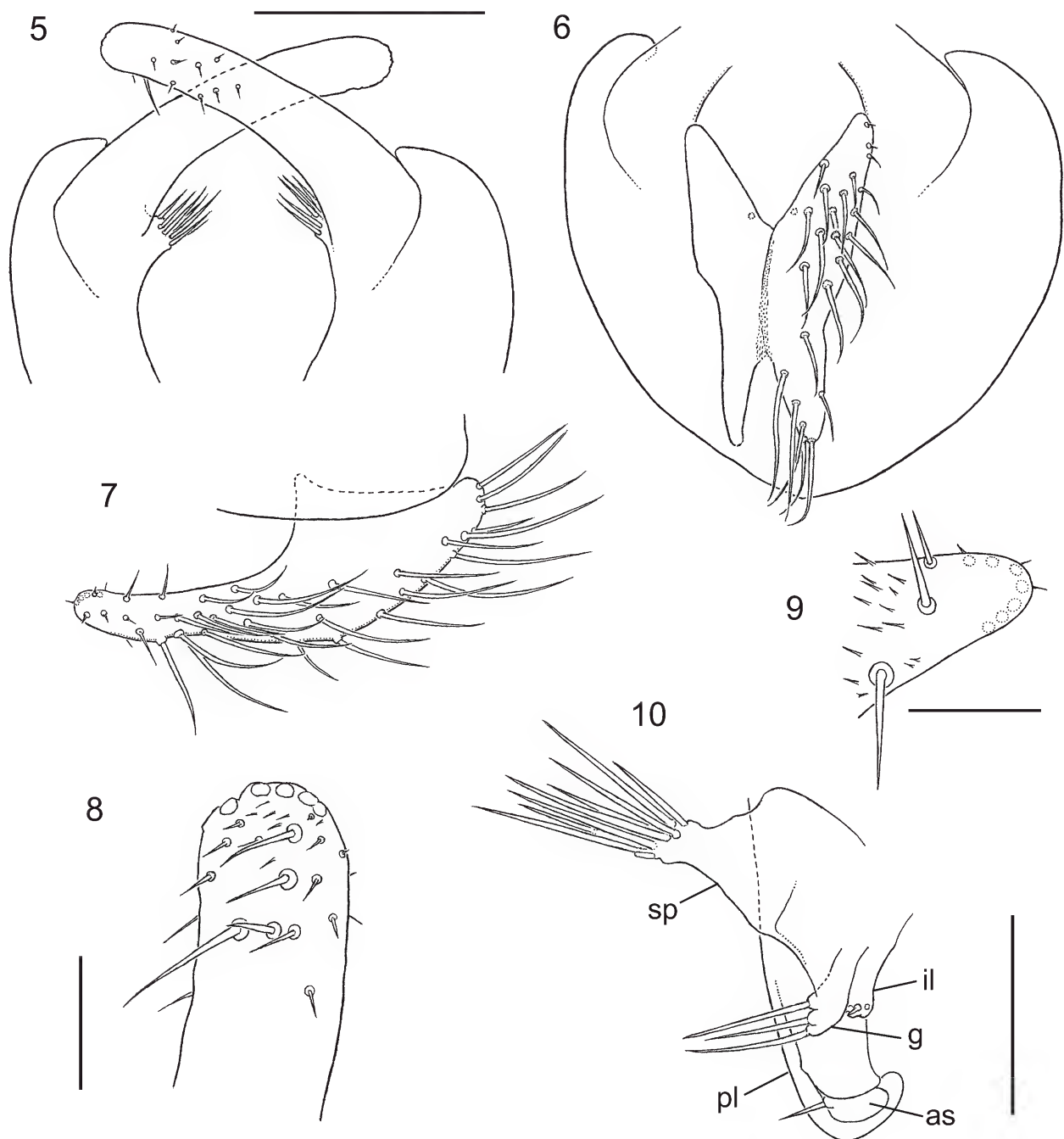
Other material examined. 24 ♀♀, similar data to type material (AM, ANIC). These are associated with above males. While identification cannot be absolutely confirmed, they are not referable to other species recorded for Mooney Mooney Creek (viz. *P. kirkspriggsi*, *P. physopus*). 1 ♂, Richmond Range, Bonalbo district, Dec. 1991, S.F.M. 8163 (AM).

### Description (male)

**Coloration** of head, body, and wings as for genus. Antenna and palpus entirely tawny-yellow. Fore femur almost entirely dark brown; mid femur entirely tawny-yellow; hind femur tawny-yellow with dark brown apex; fore and hind tibiae tawny-yellow with brown apices, the latter more strongly browned; mid tibia entirely tawny-yellow; fore and hind tarsi entirely dark brown; mid tarsus tawny-yellow with segments 4 and 5 dark brown.

**Thorax.** All tibiae slender.

**Abdomen.** Epandrium usually with two pairs of large dorsal bristles, contrasting with many small setulae; surstylus (Fig. 5) narrowly elongate, slightly broadened basally, with outer surface microtrichose on most of width except on c. distal third, with few, small setulae on parts of outer surface, on inner surface at apex not noticeably excavated, with few larger setulae and numerous minute ones some of which form a curved marginal series; inner armature consisting of low prominence or tubercle located on medial base of surstylus and bearing c. five to seven moderate-sized setulae (accurate count often difficult); subepandrial process (Fig. 10) prominent with c. eight moderately long terminal setulae; gonostylus less prominent with usually three larger setulae and a few minute ones of which little more than their globular sockets are visible, without posterodistal scabrous zone; articulating sclerite with complex apex bearing one rather long setula and few globular sockets; bulb of aedeagus without series of separate sclerites or invaginated teeth on membrane; cercus (Figs 6, 7) anteroposteriorly elongate,



Figures 5–10. *Pentachaeta edwardsi*, male; (5) surstyli *in situ*, posteroventral view; scale = 0.2 mm; (6) oblique posteroventral view of epandrium showing cerci; setulae omitted except on left cercus; scale = 0.2 mm; (7) left cercus, lateral view; (8) apex of right surstylus, inner view; scale = 0.04 mm; (9) anterior apex of right cercus, ventral (outer) view; scale = 0.04 mm; (10) left gonostylus and associated structures, lateral view; scale = 0.1 mm. *as*, articulating sclerite; *g*, gonostylus; *il*, inner lobe of gonostylus; *pl*, posterolateral extension of basiphallus; *sp*, subepandrial process (superimposed on other parts in slide preparation).

of relatively simple form, without special processes (teeth or major tubercles), densely microtrichose except towards anterior extremity, most heavily setulose before mid-length, with anterior lobe subtriangular but obtuse, slightly dorsoventrally compressed, with medial margins of two anterior lobes forming a V-shaped sinus; apex of anterior lobe with small to minute setulae, some of latter forming a curved dorsal marginal series.

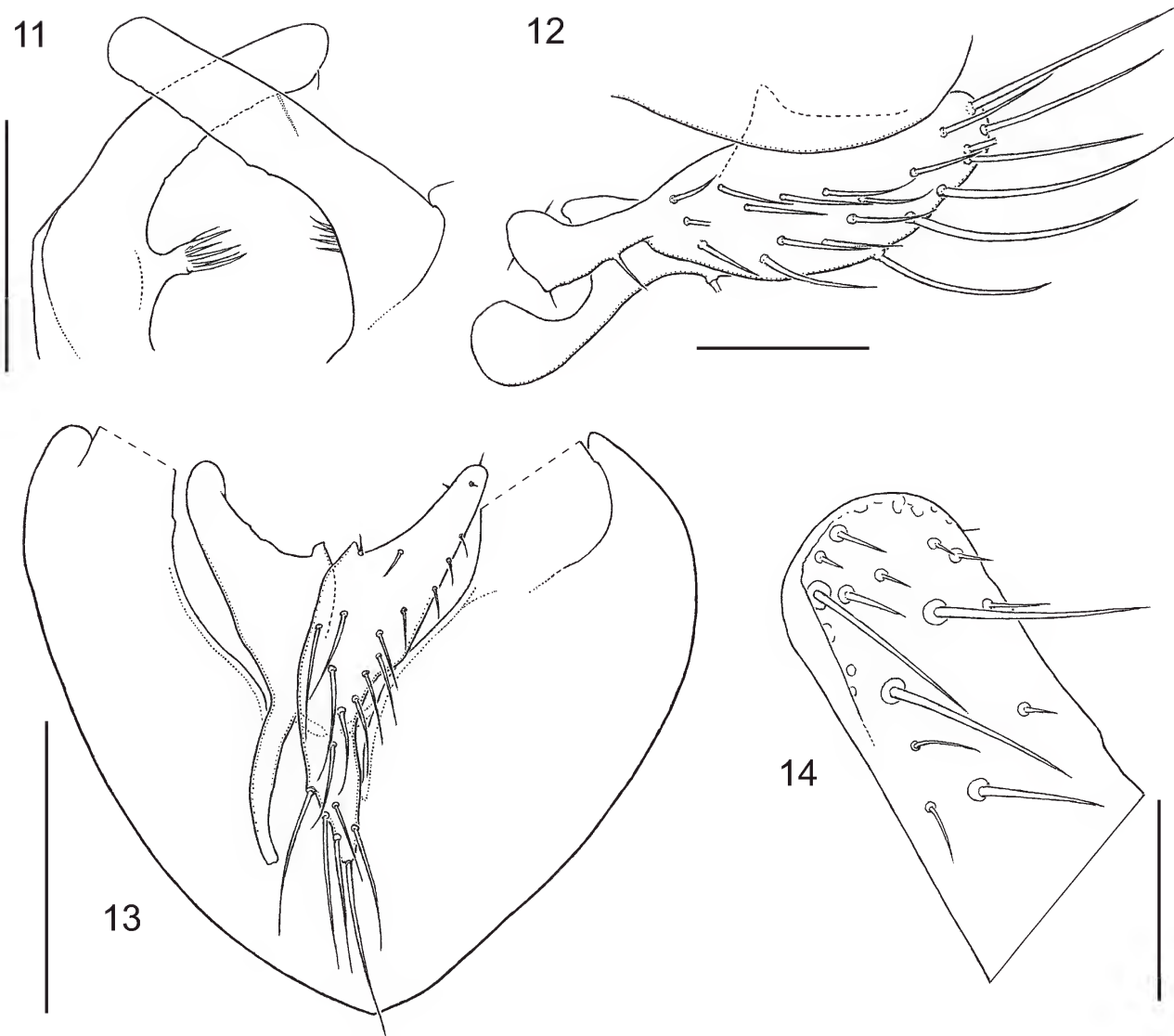
**Dimensions.** Total length, 2.2–3.1 mm; length of thorax, 1.3–1.6 mm; length of wing, 3.0–3.6 mm.

**Distribution.** Known mainly from the type locality on the northern side of Broken Bay in central eastern New South Wales; one specimen from far north-east of state. Map references 7J, 8H (Fig. 4).

### Notes

Among the species with slender, unmodified hind tibia and entirely dark brown to black fore tarsus, males of *P. edwardsi* may be distinguished by the relatively slender surstylus (Fig.





Figures 11–14. *Pentachaeta bickeli*, male; (11) surstyli, posteroventral view; minor setulae omitted; scale = 0.2 mm; (12) pair of cerci, left lateral view; setulae shown only on left cercus; scale = 0.1 mm; (13) epandrium with cerci; setulae omitted, except on left cercus; scale = 0.2 mm; (14) apex of left surstylus, inner view; scale = 0.05 mm.

5), having the basal fascicle of setulae on a short, broad gibbosity, and the anterior lobes of the cerci of simple form, without tubercle, together forming a simple V-shaped sinus, and each strongly setulose except at anterior apex. Females cannot at present be separated morphologically from those of the related species *P. bickeli*, *P. inserta*, *P. bassiana*, and *P. gilliesi*.

This species is dedicated to Frederick W. Edwards, whose careful editorial work and supplementary illustrations increased the value of J.R. Malloch's (1933) publication on south-temperate "Helomyzidae".

### *Pentachaeta bickeli* n. sp.

Figs 11–17

**Type material.** Holotype ♂. New South Wales: Mount Boyce, near Blackheath, c. 1080 m [33°37'S 150°16'E], 16.iv.1971, D.K.M. (AM K310592). On card point, some legs glued separately to card, postabdomen in genitalia tube on pin. Paratypes. New South Wales: 2♂♂, Kurrajong [Bellbird Corner, c. 33°32'S 150°38'E], Oct. 1966, Dec. 1979, B.J.D.,

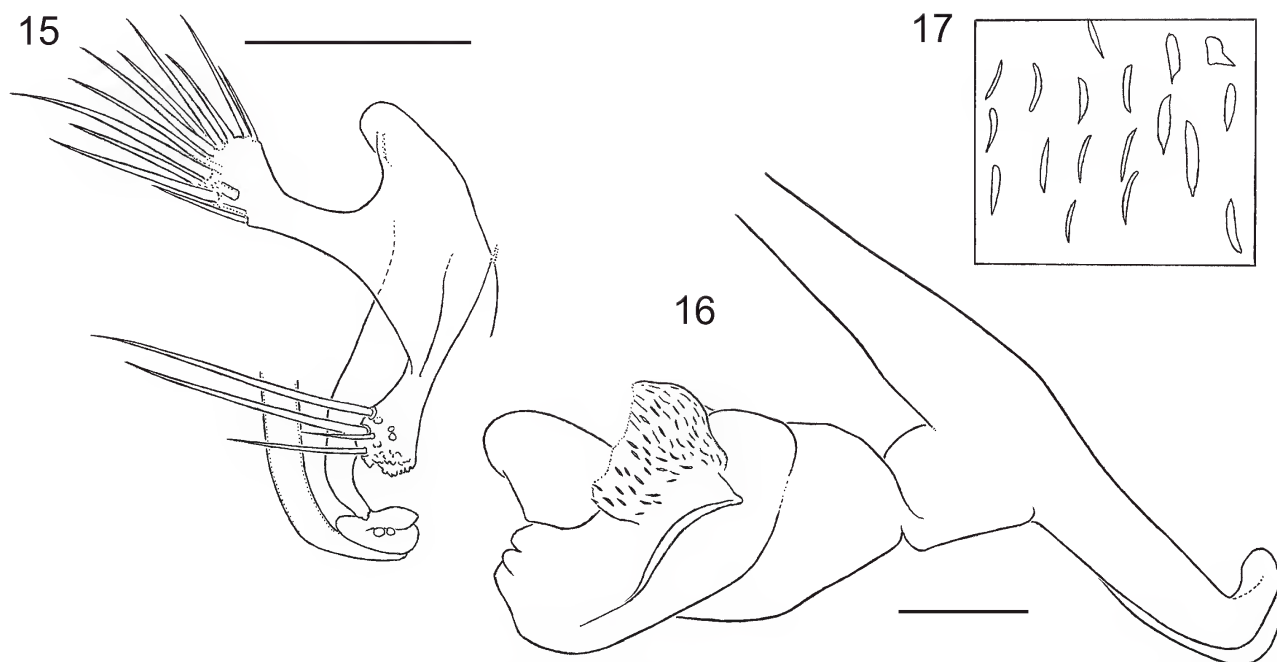
G.A.H., D.S.K., D.K.M. (AM, ANIC); 2♂♂, Wentworth Falls [c. 33°45'S 150°22'E], Nov. 1958, D.K.M. (AM); 1♂, Leura Falls, Blue Mountains, Jan. 1973, D.H.C. (ANIC); 1♂, Sassafras Gully, Springwood [c. 33°43'S 150°33'E], Nov. 1956, D.K.M. (AM); 1♂, Stoney Creek, 5.4 km NNE of Stroud, Dec. 2010, S.F.M. (AM); 1♂, 33 miles [c. 53 km] along Dorrigo–Coramba Road, Apr. 1970, D.H.C. (ANIC); 1♂, Colo Vale [Mittagong district], Mar. 1957, W.W.W. (USNM). Females are excluded from the type series because I cannot distinguish them from closely related species.

Other material examined. Queensland: North Mimosa Creek, Blackdown Tableland National Park (Expedition Range), 800 m, Sept. 1992, D.J.B. (AM, QM).

### Description (male)

Resembling *P. edwardsi* and related species without sexual dimorphism of tibiae; agreeing with description of that species, except as indicated below.

**Coloration** generally as for genus; details as given for *P. edwardsi*.



Figures 15–17. *Pentachaeta bickeli*; (15) left gonostylus and associated structures; detail as for Fig. 10; scale = 0.1 mm; (16) aedeagus, left lateral view; scale = 0.1 mm; (17) part of surface of aedeagal bulb, showing subparallel sclerotized ridges; scale = 0.05 mm.

**Abdomen.** Surstylus (Fig. 11) elongate, shaped somewhat as in *P. edwardsi*, nearly parallel-sided from before mid-length, hirsute—with many long microtrichia except towards apex, these directed or much sloped towards base, with apex (Fig. 14) on inner surface slightly excavated and with setulae of various sizes, with basal tuft of setulae on elongate, slightly clavate process which is apparently sclerotized all round; subepandrial process and gonostylus (Fig. 15) resembling those of *P. edwardsi* but rather differently shaped; gonostylus with posteroapical surface roughly pustulose and partly slightly excavate; bulb of aedeagus (Fig. 16) without invaginated conical pits, but, on left lateral surface-membrane, with many external short, narrow, subparallel sclerotized ridges, each c. 5–8  $\mu\text{m}$  long (Fig. 17); cercus (Figs 12, 13) broadened anteriorly, with angular median projection, and anteroapical lobe gradually narrowed, widely diverging from that of opposite cercus, with surface very generally finely microtrichose approximately to apex of anterior lobe, with large setulae on mid to posterior part, sparser and much smaller anteriorly, anteroapical part with very few small setulae.

**Dimensions.** Total length cannot be measured; length of thorax, 1.6–1.9 mm; length of wing, 3.9–4.2 mm.

**Distribution.** New South Wales: mountainous areas in east of state. Queensland: only known from inland ranges, W. of Gladstone district. Map references 6E, 7J, 7K, 8I (Fig. 4).

### Notes

*Pentachaeta bickeli* closely resembles other species with slender, unmodified male hind tibia, largely pale fore tibia, and entirely dark fore tarsus. Male postabdominal characters, particularly the shape of the surstylus, resemble those of *P. edwardsi* and *P. inserta*, but the species differs from *P. edwardsi* in the more elongate setulose tubercle on base of surstylus, in the differently shaped cercus with differently distributed setulae and small, angular medial projection

almost level with its ventral surface, and in details of the subepandrial process and gonostylus. It differs from *P. inserta* particularly in the shape of the cercus and the absence of invaginated subconical teeth on the aedeagus, but these are replaced by numerous minute external ridges (Fig. 17). I am unable to distinguish females from those of related species.

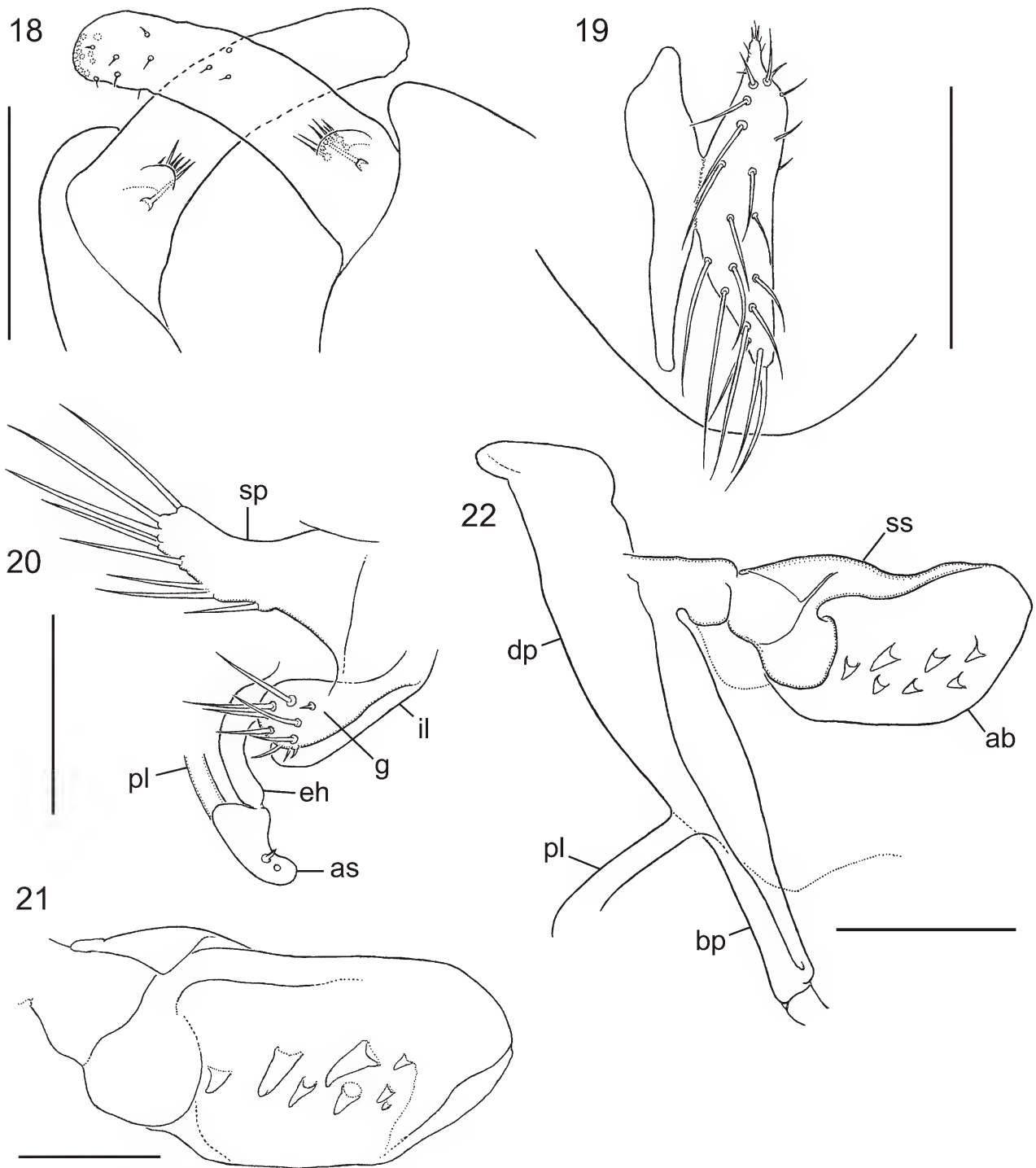
The specific epithet refers to Daniel J. Bickel who has collected significant material and given much support to this study.

### *Pentachaeta inserta* n. sp.

Figs 18–22

**Type material.** Holotype ♂. New South Wales: Mount Wilson, Blue Mountains, c. 33°31'S 150°23'E, c. 900 m, 5.xi.1977, D.K.M. (AM K310593). Glued to card point, postabdomen in genitalia tube on same pin. Paratypes. New South Wales: 10♂♂, Mount Wilson, Jan., Mar., Oct., Nov., Dec., 1956–2002, D.K.M. (AM, USNM); 1♂, Putty Road at Tinda Creek, Oct. 1987, D.K.M. (AM); 1♂, Victoria Falls, Blue Mountains, Nov. 1965, D.K.M. (AM); 1♂, Wentworth Falls, Nov. 1958, D.K.M. (AM); 3♂♂, Jenolan Caves, no date, J.C.W. (AM).

Other material examined. New South Wales: Hungry Head, near Urunga (AM); Mongalowe River, Monga Road (ANIC); Clyde Mountain, 2400 ft [c. 730 m] (AM); Clyde Mountain, Cabbage Tree Creek (ANIC); Rutherford Creek, Brown Mountain (ANIC); Tantawangalo Forest, near Candelo (AM); Saw Pit Creek, Snowy Mountains (AM); Maxwell's Creek, Nadgee State Forest (AM). Victoria: Bucklands, East Gippsland (ANIC); Dynamite Creek, Bonang Highway (ANIC); Martin's Creek, Bonang Highway (AM); Tunnel Bend, near Jamieson (AM); Myer's Creek, near Healesville (ANIC); Fernshaw, near Healesville (AM); Warburton (AM); Belgrave, near Melbourne (AM),



Figures 18–22. *Pentachaeta inserta*, male, Mount Wilson; (18) pair of surstyli, posteroventral view; structures on inner surface of basal half seen through transparency; scale = 0.2 mm; (19) pair of cerci, oblique ventral view; setulae shown only on left cercus; scale = 0.2 mm; (20) left gonostylus, subepandrial process, and associated structures; scale = 0.1 mm; (21) bulb of aedeagus, left lateral view, showing invaginated sclerotized teeth; scale = 0.1 mm. *Pentachaeta inserta*, male, Belgrave; (22) left lateral view of aedeagus; scale = 0.2 mm. *ab*, aedeagal bulb; *as*, articulating sclerite; *bp*, basiphallus; *dp*, distiphallus; *eh*, sclerotized extension of hypandrium; *g*, gonostylus; *il*, inner lobe of gonostylus; *pl*, posterolateral extension of basiphallus; *sp*, subepandrial process; *ss*, minutely scabrous sclerite of bulb.

MV, USNM); Sherbrooke Forest, near Ferntree Gully (AM, ANIC); Splitters Falls, Wannon River, and Mount William, Grampians National Park (AM). Tasmania: 2 miles [c. 3 km] east of Tonganah, Scottsdale district (AM); Pieman River, near Rosebery (AM); Renison Bell, Pieman River district (AM); "Nat. Park" [Mount Field National Park] (ANIC).

#### Description (male)

Resembling *P. edwardsi* and related species without sexual dimorphism of tibiae; agreeing with description of that species, except as indicated below.

*Coloration* generally as for genus; details as given for *P. edwardsi*.



**Abdomen.** Surstylus (Fig. 18) moderately elongate, only slightly tapering distally, with many long microtrichia on c. basal two thirds of length on outer surface, apically rounded with very small setulae, some crowded at extreme tip, with one or few larger setulae on subapical part of inner surface, with tuft of short to medium-sized setulae on very short cap-like, slightly convex sclerite at base of inner surface, often a moderately large setula located near tuft; subepandrial process (Fig. 20) moderately slender, with large but not dense setulae; gonostylus tumid and rounded distally, with rather large setulae and some smaller posterior ones, without scabrous or pustulose zone, subtended by a simple sheathing lobe; aedeagus (Fig. 22); membranous surface of bulb with six to ten invaginated, subconical sclerotized teeth of various sizes; cercus (Fig. 19) densely microtrichose, except anteriorly, not much broadened near mid-length, but slightly gibbous before anterior extremity, which forms a simple, anteriorly directed, slightly narrowed papilla bearing minute setulae, in contrast to large setulae on most of length of cercus.

**Dimensions.** Total length 3.1–3.5 mm; length of thorax, 1.6–1.7 mm; length of wing, 4.0–4.3 mm.

**Distribution.** New South Wales: mainly mountainous districts, but recorded for North Coast (Hungry Head). Victoria: widely distributed as far west as Grampians National Park. Tasmania: probably widely distributed. Map references 3L, 4L, 4N, 5L, 5N, 5O, 6K, 6L, 7J, 7K, 8I (Fig. 4).

### Notes

Among the species with predominantly pale fore tibia and no sexual dimorphism of the tibiae, males of *P. inserta* are distinguished by the form of the cercus, which lacks distinctive armature, the distally rounded gonostylus, which lacks a scabrous or pustulose zone, and by the presence of invaginated conical teeth on bulb of the aedeagus (Figs 21, 22). Nothing approaching these structures has been observed in other species.

The specific epithet is a Latin adjective referring to the invaginated teeth inserted in the bulb of the aedeagus.

### *Pentachaeta bassiana* n. sp.

Figs 23–25

**Type material.** Holotype ♂. Tasmania: Marakooa Caves, near Mole Creek, c. 41°35'S 146°17'E, 10.i.1960, D.K.M. (AM K310594). Glued to card point, surstyli exposed, postabdomen not dissected. Paratypes. Tasmania: 2♂♂, same data as holotype (AM); 2♂♂, Hellyer Gorge, upper (eastern) Arthur River district, Feb. 1967, E.F.R. (ANIC); 2♂♂, 2 miles [c. 3 km] E of Tonganah, near Scottsdale, Jan. 1960, D.K.M. (AM); 1♂, near Russell Falls, Mount Field National Park, Jan. 1960, D.K.M. (AM).

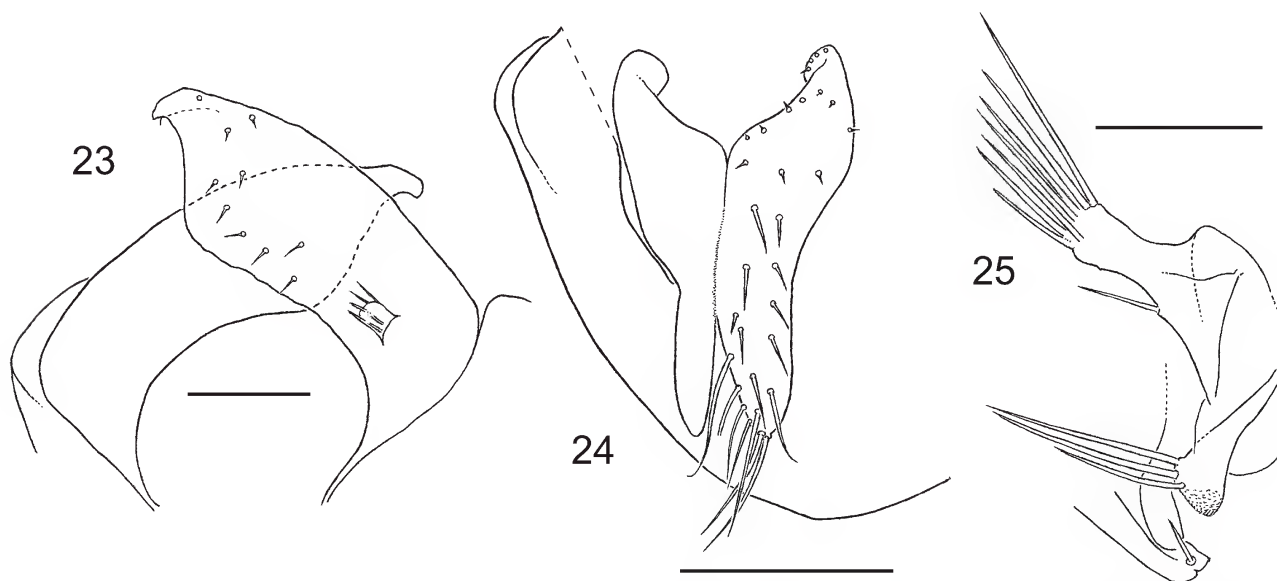
Other material examined. Males. Victoria: Belgrave, near Melbourne (AM, MV).

### Description (male, females not yet identifiable)

Resembling *P. edwardsi* and related species without sexual dimorphism of tibiae; agreeing with description of that species, except as indicated below.

**Coloration** generally as for genus; details as given for *P. edwardsi*.

**Abdomen.** Surstylus (Fig. 23) with basal foot extended narrowly on margin of epandrium posteriorly, much broadened near and beyond mid-length but contracted to short, narrow apical section, on most of outer surface densely microtrichose but with few minute macrotrichia, apically with several larger macrotrichia on inner surface, basally on inner surface with compact sclerotized tubercle bearing few short macrotrichia; subepandrial process (Fig. 25) somewhat resembling that of *P. edwardsi*; gonostylus more nearly resembling that of *P. bickeli*, with typically three long macrotrichia and scabrous zone which varies from slightly convex to slightly concave; aedeagus without invaginated teeth; cercus (Fig. 24) somewhat elongate, but expanded anteriorly to mid-length, with the pair of anterior lobes strongly diverging, each apically compressed, rounded and slightly twisted, outer surface with large macrotrichia



Figures 23–25. *Pentachaeta bassiana* (23) pair of surstyli, posteroventral view (Marakooa Caves); structure on inner surface of basal half seen through transparency; scale = 0.1 mm; (24) pair of cerci, oblique ventral view (Belgrave); setulae shown only on left cercus; scale = 0.2 mm; (25) left gonostylus, subepandrial process and associated parts (Marakooa Caves); scale 0.1 mm.

posteriorly, minute ones anteriorly, and with general covering of microtrichia, but without distinctly angular outline and tubercle.

**Dimensions.** Total length 3.3–3.6 mm; length of thorax, 1.5–1.8 mm; length of wing, 4.1–4.6 mm.

**Distribution.** Tasmania: probably widely distributed. Victoria: vicinity of Melbourne. Map references 4L, 4N, 5N, 5O (Fig. 4).

### Notes

*Pentachaeta bassiana* belongs among those species without sexual dimorphism of the tibiae and with entirely dark male fore tarsus. Among these, the male has the surstylus with quite distinctive shape (Fig. 23), and the cercus is also characteristic. The specimen examined from Belgrave, Victoria, differs from the Tasmanian specimens (Marakooa Caves and Hellyer Gorge) in having the surstylus slightly broader, the anterior lobe of the cercus shorter, and the setulae on the subepandrial process and gonostylus more numerous. These differences are slight, and study of more material is needed before significant divergence between the Victorian and Tasmanian populations can be accepted.

The specific epithet has the form of a Latin adjective and refers to the occurrence of the species on both sides of the Bass Strait.

### *Pentachaeta skusei* n. sp.

Figs 26–29

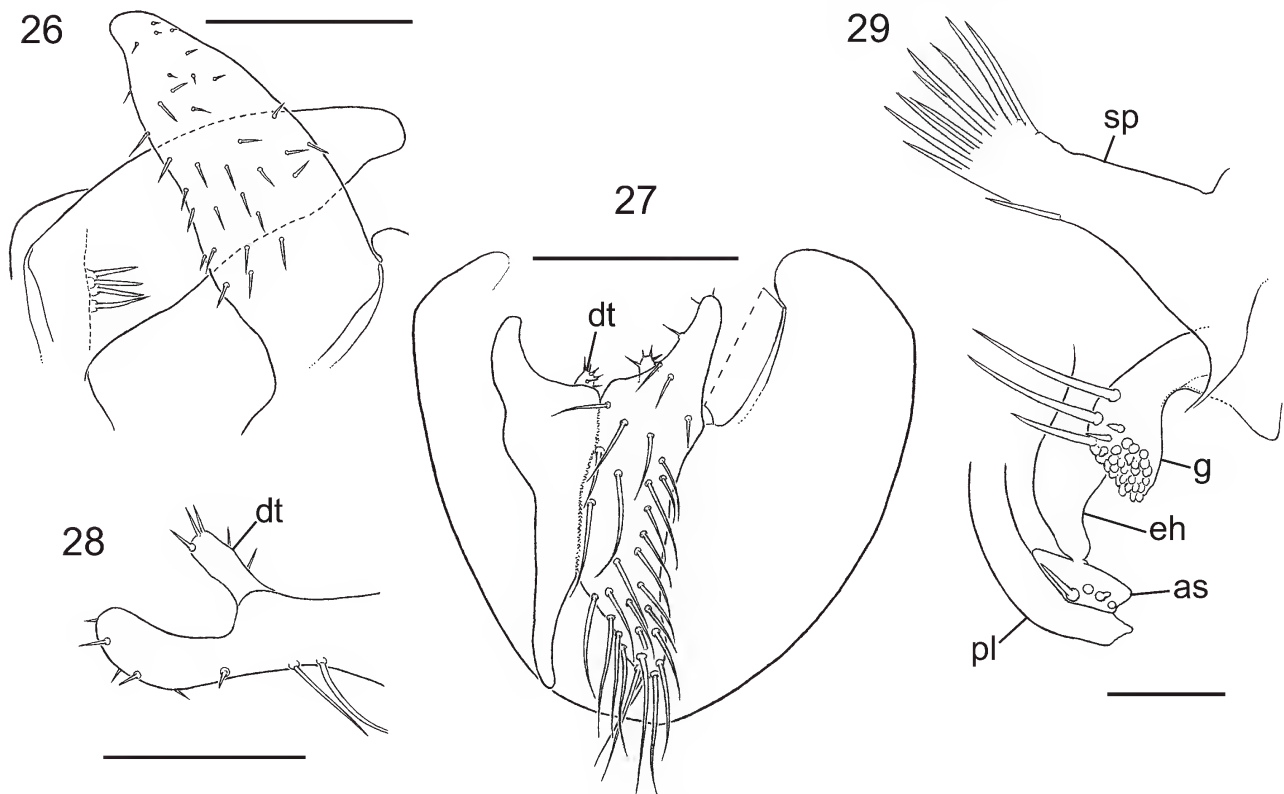
**Type material.** Holotype ♂. Victoria: Belgrave, near Melbourne, [probably margin of Sherbrooke Forest, c. 37°53'S 145°22'E], 21.i.1966, D.K.M. (AM K310595). Glued to card point, postabdomen in genitalia tube on same pin. Paratypes. Victoria: 2♂♂, Ninks Road, Kinglake, Jan 1980, B.W.B. (ANIC). New South Wales: 1♂, below Govett's Leap, Blue Mountains, Dec. 1956, D.K.M. (AM).

### Description (male)

Resembling *P. edwardsi* and related species without sexual dimorphism of tibiae; agreeing with description of that species, except as indicated below.

**Coloration** generally as for genus; details as given for *P. edwardsi* except as here noted. Fore femur orange-tawny, becoming brownish dorsally (perhaps faded in old type specimens); fore tarsus with segments 1 and 5 brown or largely brown, segments 2 to 4 pale tawny-yellow; mid tarsus tawny yellow, indistinctly brownish distally in faded specimens; hind tarsus dark brown.

**Abdomen.** Surstylus (Fig. 26) ovate-lanceolate, distally gradually tapering to obtuse apex, outer surface extensively microtrichose, also with scattered short but rather stout setulae, which may be more numerous on posterior part of outer surface, apical part of inner surface with few setulae of variable size and marginal group of minute setiferous tubercles, at base of inner surface fascicle of short, stout



Figures 26–29. *Pentachaeta skusei*, male, Govett's Leap (26) pair of surstyli, posteroventral view; setulae shown only on left surstylus and on prominence of inner basal surface of right surstylus (latter seen through transparency); scale = 0.2 mm. *Pentachaeta skusei*, Belgrave (27) epandrium with cerci, setulae shown only on left cercus and dorsal tubercles; scale = 0.2 mm; (28) medial view of anterior lobe of right cercus; scale = 0.1 mm. *Pentachaeta skusei*, Govett's Leap (29) left gonostylus, subepandrial process and associated parts, lateral view; scale = 0.05 mm. *as*, articulating sclerite; *dt*, dorsal setulose tubercle of cercus; *eh*, sclerotized extension of hypandrium; *g*, gonostylus; *pl*, posterolateral extension of basiphallus; *sp*, subepandrial process.

setulae, either not arising from a common prominence, or on very slight prominence; subepandrial process (Fig. 29) with numerous stout setulae towards apex and on inner surface; apex of gonostylus with three or four large setulae and sometimes few much smaller ones, with flat or slightly concave posterodistal densely pustulose zone; bulb of aedeagus without invaginated teeth; cercus (Figs 27, 28) narrowly extended posteriorly, much broadened across base of anterior lobe, with pair of anterior lobes strongly divergent, at broadest part with prominent dorsal (and thus partly concealed) setulose tubercle (Figs 27, 28), on exposed ventral surface with extensive armature of large setulae, becoming sparser and finer on anterior lobe.

*Dimensions.* Total length 3.2 mm; length of thorax, 1.3–1.6 mm; length of wing, 3.4–4.0 mm.

**Distribution.** New South Wales: Blue Mountains. Victoria: forested areas E and NE of Melbourne. Map references 4L, 7J (Fig. 4).

### Notes

*Pentachaeta skusei* belongs among those species without sexual dimorphism of the tibiae and with the fore tibia tawny yellow with brown apex. It differs from other such species in having segments 2 to 4 of the fore tarsus tawny yellow (dark brown in related species). The form of the surstylus (Fig. 26) is distinctive, though somewhat resembling that of *P. gilliesi*, but the male cercus is very different (compare Figs 27 and 30). I suspect that the unknown female will be distinguishable from related species by the coloration of the fore tibia and tarsus, as in the male.

This species is dedicated to Frederick A. Skuse, the first Diptera specialist employed at the Australian Museum.

### *Pentachaeta gilliesi* n. sp.

Figs 30–33

**Type material.** Holotype ♂. South Australia: Mount Bonython, near Mount Lofty, c. 34°58'S 138°42'E, 12.iv.1967, D.K.M. (AM K310596). Glued to card point, postabdomen in genitalia tube on same pin. Paratypes. South Australia: 1♂, summit, Mount Lofty, Apr. 1967, D.K.M. (AM); 4♂♂, “Sunders”, near Hackham, Adelaide district, May 1975, H.A. (SAM, AM); 1♂, “Kurlge”, Blackwood, 850 feet [c. 259 m], May 1958, N.B.T. (SAM).

Other material examined. Males. Australian Capital Territory: Black Mountain, near Canberra (ANIC, AM). Some female specimens from the following localities are associated with males of *P. gilliesi* and perhaps may be conspecific: Sunders, near Hackham (SAM); Blackwood (SAM); Black Mountain (ANIC).

### Description (male)

Resembling *P. edwardsi* and related species without sexual dimorphism of tibiae; agreeing with description of that species, except as indicated below.

*Coloration* generally as for genus, with some details as in description of *P. edwardsi*.

*Abdomen.* Epandrium with only one pair of well differentiated dorsal bristles; surstylus (Fig. 31) less elongate than in *P. edwardsi* and *P. inserta*, somewhat narrowed distally, but very obtuse, on outer surface with many short microtrichia and very few small macrotrichia, on inner surface near apex with macrotrichia of very diverse sizes (Fig. 32), near base on inner surface without usual fascicle of setulae, but with one to three long setulae in a series approaching subepandrial process; subepandrial process forming short, broad setulose tubercle; gonostylus bilobed, anterior lobe with few large setulae, posterior lobe separately prominent, with few minute setulae but no scabrous or pustulose zone; bulb of aedeagus without invaginated teeth; cercus (Fig. 30) scarcely produced posteriorly, anteriorly very prominently elongate, almost parallel-sided, towards anterior apex obtuse, minutely setulose, posterior half of cercus setulose, with many of larger setulae in a single series.

*Dimensions.* Total length 2.6–2.9 mm; length of thorax, 1.2–1.3 mm; length of wing, 3.2–3.6 mm.

**Distribution.** Only known from the Adelaide Hills district, South Australia, and the Canberra district, Australian Capital Territory. These two districts, about 900 km apart, are of similar latitude (around 35°S). They are drier than most *Pentachaeta* habitats, and other *Pentachaeta* species are not recorded for the districts. It is conceivable that *P. gilliesi* may yet be found in intermediate localities. Map references 1K, 6K (Fig. 4).

### Notes

*Pentachaeta gilliesi* closely resembles *P. edwardsi* and related species and is at present only distinguishable from these on male postabdominal characters. The long, narrow cerci (Fig. 30) are so distinctive that males with these exposed are easily identified. Another distinctive feature is the presence of only one pair of stout dorsal bristles on the epandrium, and the form of the surstylus (Fig. 31) is fairly distinctive, though somewhat resembling that of *P. skusei*.

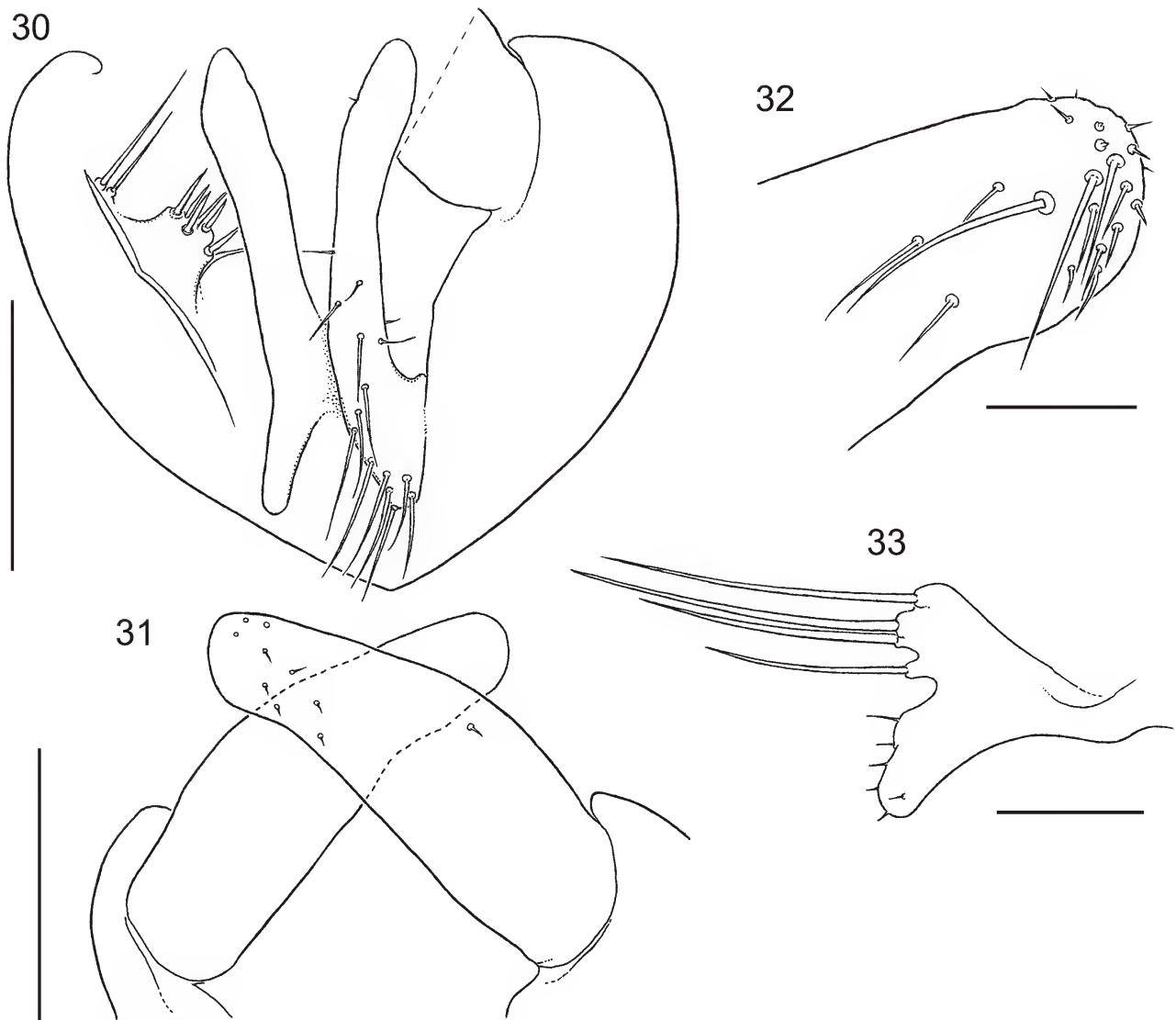
This species is dedicated to William Gillies, whose elementary but thoughtfully prepared book (c. 1909) served as my childhood introduction to entomology.

### *Pentachaeta impar* n. sp.

Figs 34–36

**Type material.** Holotype ♂. New South Wales: Wilson River Reserve, near Bellangry, [c. 31°12'S 152°29'E], 24.ix.1981, D.K.M., B.J.D. (AM K310597). Glued to card point, postabdomen not dissected. Paratypes. New South Wales: 112♂♂, 69♀♀, same locality as holotype, Jan., Mar., Sept., Nov., Dec., 1966–1986, D.K.M., B.J.D., D.J.B. (AM, ANIC, USNM); 6♂♂, 2♀♀, Cambridge Plateau, Kyogle district, Jan. 1993, S.F.M. (AM); 1♂, 2♀♀, Terania Creek, Lismore district, Feb. 1980, D.K.M., B.J.D. (AM); 4♂♂, Whian Whian State Forest, Lismore district, Feb. 1965, 1980, D.K.M., B.J.D. (AM); 10♂♂, 8♀♀, Huonbrook, near Mullumbimby, Jan., Feb., Mar. 1961–1965, D.K.M., R.L. (AM, QM); 3♂♂, 2♀♀, Mount Gibraltar National Park, c. 64 miles [103 km] W





Figures 30–33. *Pentachaeta gilliesi*, Mount Bonython (30) epandrium with cerci, showing right subepandrial process and basal prominence of right surstylus; scale = 0.2 mm; (31) pair of surstyli, posteroventral view; setulae shown only on left surstylus; scale = 0.2 mm; (32) apex of left surstylus, inner surface view; scale = 0.05 mm; (33) left gonostylus, lateral view; scale = 0.05 mm.

of Grafton, Feb. 1965, D.K.M. (AM); 19♂♂, 15♀♀, Bruxner Park, near Coffs Harbour, Feb., Oct., Nov., 1962–1965, D.H.C., D.K.M., M.S.U. (AM, ANIC); 3♂♂, 4♀♀, near N.W. Jolly Memorial Grove, Moonpar State Forest, Dorrigo district, Mar. 1987, D.K.M., B.J.D., R.d.K. (AM); 4♂♂, 2♀♀, Dorrigo National Park, Jan. Mar., 1960, 1961, D.K.M. (AM); 2♂♂, The Dome (McGrath's Hump), near Dorrigo, Mar. 1960, D.K.M. (AM); 2♀♀, Middle Brother State Forest, near Kendall, Feb. 1990, D.K.M. (AM); 1♂, Lorien Wildlife Refuge, near Lansdowne, Sept. 2010, G.A.W. (AM).

Other material examined. Queensland: Summer Creek, Little Yabba Forestry Road, near Kenilworth (AM); Mount Glorious, near Brisbane (AM); Mount Tamborine (AM); Binna Burra, Lamington National Park (AM); Cunningham's Gap, near Maryvale (ANIC).

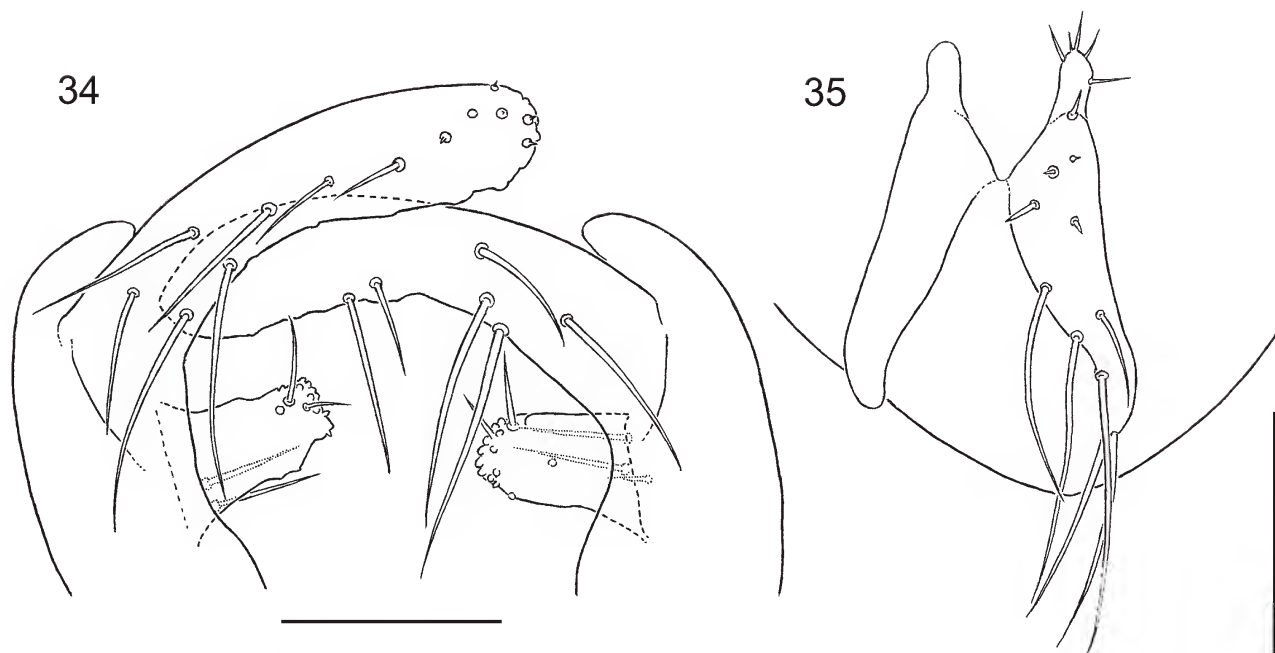
**Description** (male, female). General characters as for genus.

**Coloration** of head, body, and wings, as for genus. Antenna predominantly tawny-yellow, with segment 3 slightly suffused with light brown; palpus tawny-yellow with brown

apex. Sternopleuron tawny-yellow; with upper margin suffused with brown. Fore femur entirely brown; mid and hind femora tawny-yellow, with brown apices, tibiae tawny-yellow, hind tibia with brownish base and apex; fore and hind tarsi brown; mid tarsus tawny-yellow, becoming brownish apically.

**Thorax.** Hind tibia thickened in male only, other tibiae slender, normal.

**Abdomen** (male). Epandrium with two pairs of large bristles and numerous setulae, produced into a marginal tubercle anteriorly to base of surstylus; surstylus (Fig. 34) elongate, almost parallel-sided in part, rounded apically, slightly broadened at extreme base, densely microtrichose on most of outer surface, with several large setulae, some nearly half as long as surstylus, and minute apical setulae, without inner basal prominence; subepandrial process large and prominent with few small setulae and minute tubercles distally, dorsobasally with two or three larger setulae; gonostylus compact, simple, with two to four large setulae; distiphallus long, tapered, channelled, with membranous



Figures 34, 35. *Pentachaeta impar*, Wilson River Reserve; (34) surstyli, with subepandrial processes; scale = 0.1 mm; (35) cerci, oblique ventral view; setulae shown only on left surstylus; scale = 0.1 mm.

oblong ventral lobe; bulb of aedeagus of unusual shape with pair of apertures on funnel-like anterior processes; cercus (Fig. 35) moderately elongate, extensively microtrichose on both inner and outer surfaces, with relatively few large posteriorly directed setulae, and rather short subcylindrical, blunt, non-microtrichose anterior process, usually somewhat gibbous ventrally at base of process.

**Dimensions.** Total length, ♂ 2.0–2.4 mm, ♀ 2.4–2.8 mm; length of thorax, ♂ 1.1–1.3 mm, ♀ 1.3–1.4 mm; length of wing, ♂ 2.8–3.1 mm, ♀ 3.2–3.7 mm.

**Distribution.** Mainly coastal and subcoastal districts of southern Queensland and northern New South Wales, from Kenilworth district in north to Taree district in south. Map references 8G, 8H, 8I (Fig. 4).

### Notes

*Pentachaeta impar* is distinct from all other species of the genus in that the male has only the hind tibia markedly thickened, the other tibiae being slender as in the female. The aedeagus is peculiar in the structure of the distiphallus and the presence of a pair of funnel-like openings on the bulb. Both sexes can generally be distinguished from other *Pentachaeta* species by presence of a brown suffusion on the upper margin of the sternopleuron (katapisternum).

The specific epithet is a Latin adjective, *impar*, unequal, in reference to the difference in thickness between the hind tibia and the other tibiae in the male.

### *Pentachaeta kirksprigsi* n. sp.

Figs 37–39

**Type material.** Holotype ♂. New South Wales: Wentworth Falls, Blue Mountains [c. 33°45'S 150°22'E], 2.ii.1957, D.K.M. (AM K310598). Glued to card point. Paratypes. New South Wales: 6♂♂, 3♀♀, same locality as holotype, Feb., Nov., Dec., 1957–1982, D.K.M., B.J.D., K.C.K. (AM); 1♀, Katoomba, Nov. 1958, G.H.H. (AM); 1♂, 2♀, Sassafras Gully, Springwood, Sept., Nov., 1956–1972, D.K.M. (AM); 3♂♂, 2♀♀, Mount Wilson, Blue Mountains, Oct., Nov. 1958–1982, D.K.M. (AM); 1♀, Kurrajong, Oct. 1966, D.K.M., G.A.H. (AM); 1♂, 1♀, Cambridge Plateau, near Tunglebung, Kyogle district, Nov. 1993, S.F.M. (AM); 3♂♂, 1♀, Never Never Creek, Promised Land, near Bellingen, Nov. 2003, D.K.M. (AM); 1♂, Wilson River Reserve, near Bellangry, Nov. 1966, D.K.M. (AM); 1♂, “Tuglo”, 48 km N of Singleton, Dec. 1981, G.A.H. (AM); 2♀, Upper Allyn, near Eccleston, Nov. 1965, D.K.M. (AM); 21♂♂, 21♀♀, Mooney Mooney Creek, near Gosford, Jan., Nov., Dec. 1975–1989, D.K.M., B.J.D. (AM, ANIC, USNM); 2♀♀, Church Point, near Sydney, Feb., Nov. 1983–1989, D.K.M. (AM); 1♂, 1♀, Wahroonga, near Sydney, Oct. 1926, anon. (AM); 1♀, Soldiers Memorial Park, Lindfield, near Sydney, May 1976, C.N.S., G.D. (AM); 1♀, Bankstown, near Sydney, Apr. 1981, B.J.D. (AM); 1♂, 2♀♀, Royal National Park, near Sydney, Nov., Dec. 1965–2003, D.K.M. (AM); 1♂, Colo Vale, near Mittagong, Jan. 1957, W.W.W. (USNM); 1♀, East Kangaloon, near Robertson, Nov. 1989, D.K.M. (AM).

**Description (male, female)**

*Coloration* of head, body, and wings, as for genus. Antenna and palpus tawny-yellow, latter without trace of darkened apex. Fore femur almost entirely dark brown; mid and hind femora yellow, latter sometimes slightly darkened apically; fore tibia brown in male, yellow in female, brown at most only on extreme base; mid tibia yellow; hind tibia brown in male, yellow with brown apex in female; tarsi yellowish, becoming darker distally.

*Thorax.* All tibiae strongly swollen in male, slender in female.

*Abdomen* (male). Epandrium with two pairs of large dorsal bristles and numerous setulae; surstylus (Fig. 37) slightly curved, almost parallel-sided, but often slightly narrowed towards base, broadly rounded at apex, with numerous microtrichia on somewhat less than basal half of outer surface but none on inner surface, and with scattered setulae, some of which are moderately large; inner basal prominence of surstylus broadly transverse, with very few setulae; subepandrial process (Fig. 39) prominent, usually not much narrowed distally, with usual large distal setulae; gonostylus with few long setulae and posterodistal tuberculose zone; cercus (Fig. 38) rather stout, with large setulae and numerous microtrichia on entire length, with anterior lobe moderately produced and apically dilated and bilaterally compressed to slightly variable degree.

*Dimensions.* Total length, ♂ 2.4–2.9 mm, ♀ 2.6–2.9 mm; length of thorax, ♂ 1.2–1.4 mm, ♀ 1.3–1.4 mm; length of wing, ♂ 3.0–3.4 mm, ♀ 3.1–3.4 mm.

*Distribution.* Eastern New South Wales—mainly sub coastal areas and nearby ranges from Kyogle district to near Robertson, also Blue Mountains. Map references 7J, 7K, 8H, 8I (Fig. 4).

**Notes**

*Pentachaeta kirkspriggsi* belongs among those species with all tibiae much thickened in the male, and the fore tibia yellowish without apical brown mark in the females. Among these species, distinctive features include the entirely yellow palpus and the absence of a broad brownish zone on the upper part of the sternopleuron. In the male, the shape of the anterior lobe of the cercus is distinctive (Fig. 38), and the shape of the surstylus (Fig. 37) distinguishes it from some species.

The specific epithet refers to Ashley H. Kirk-Spriggs, who has generously provided study material of African Diptera.

***Pentachaeta pinguis* n. sp.**

Figs 1, 40–42

**Type material.** Holotype ♂. New South Wales: Royal National Park, lower end of Waterfall Creek, 34°09'S 151°01'E, 25.xii.2003, D.K.M. (AM K310599). Glued to card point, postabdomen in genitalia vial on same pin. Paratypes. New South Wales: 2♂♂, 2♀♀, same locality as holotype, Mar., Dec., 2003–2012, D.K.M. (AM, ANIC); 1♂, 2♀♀, [Royal] National Park, Nov. 1960–1965, D.K.M. (AM); 2♂♂, 12♀♀, Terania Creek, near Lismore, Feb. 1980–1983, D.K.M., B.J.D., K.C.K. (AM); 1♂, Whian Whian State

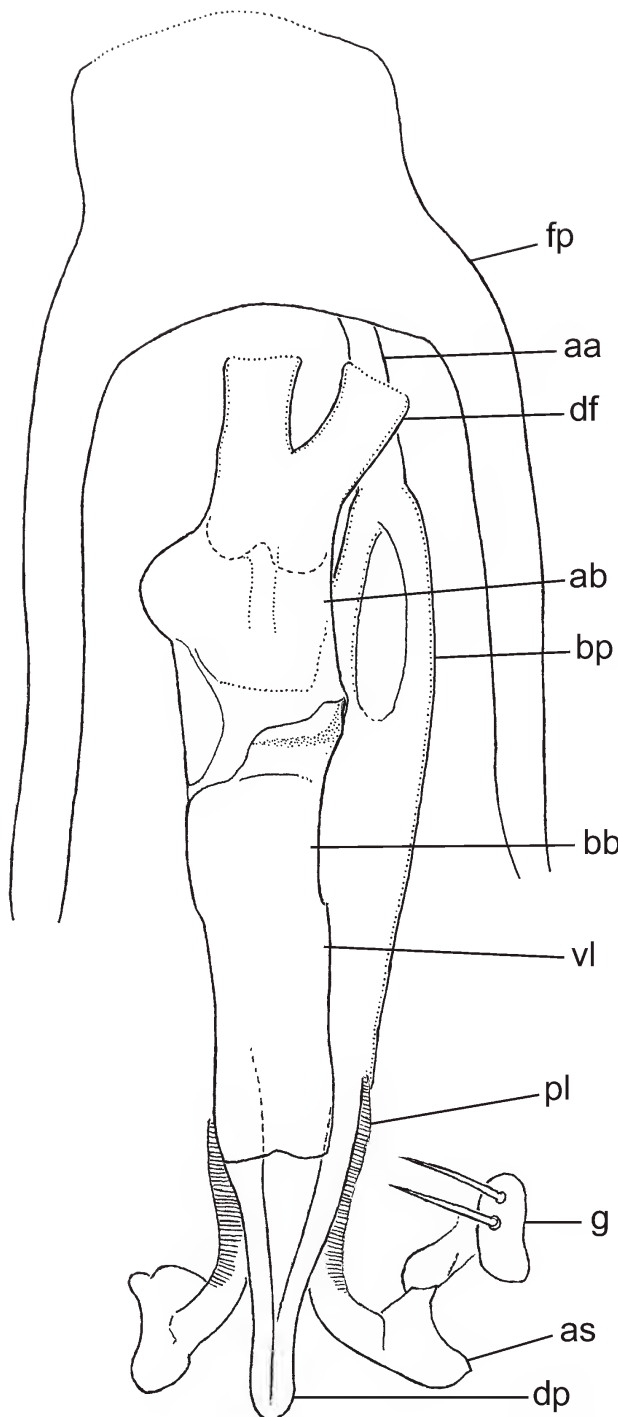
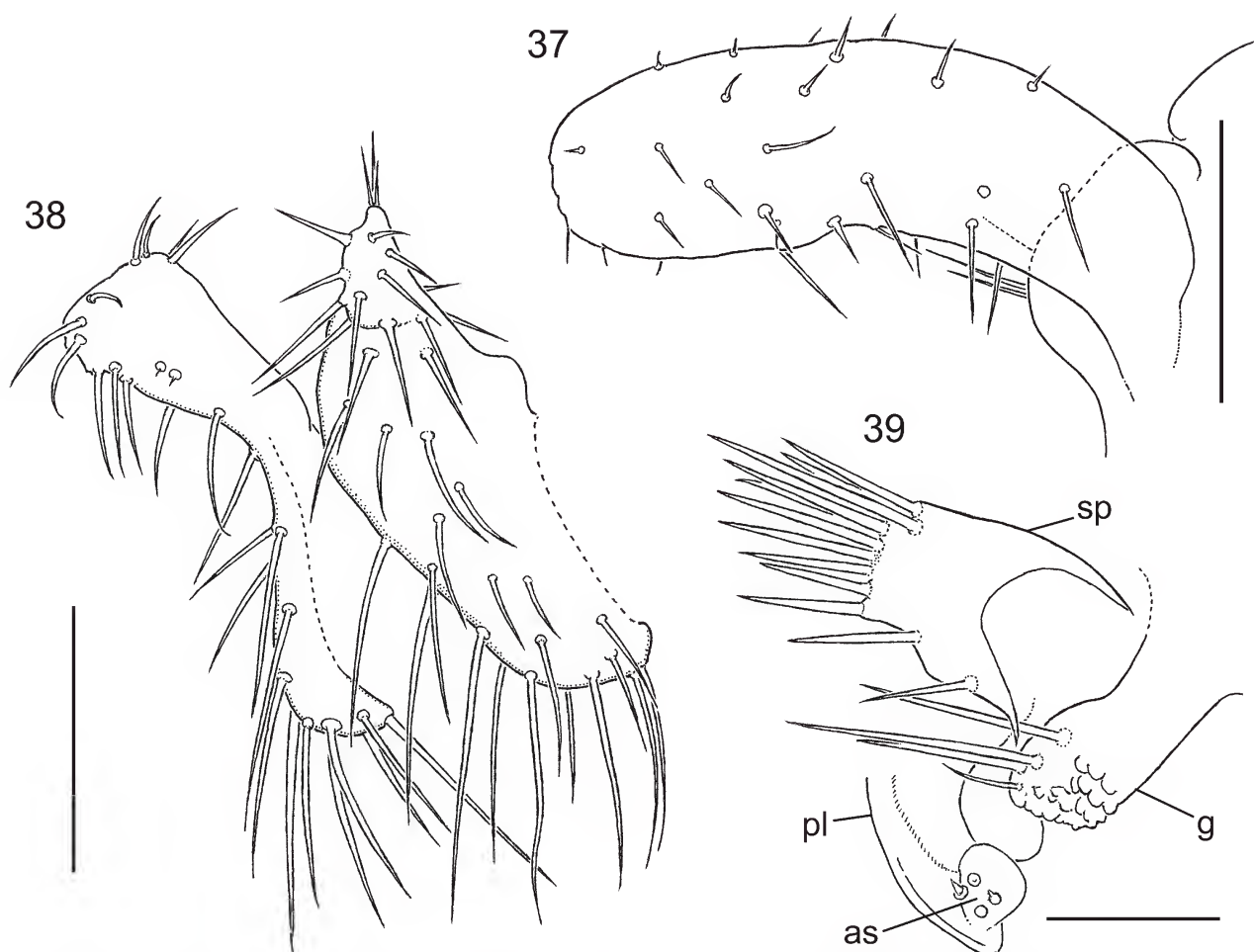


Figure 36. *Pentachaeta impar*, Wilson River Reserve. Hypandrium and associated structures, ventral view. *aa*, aedeagal apodeme; *ab*, aedeagal bulb; *as*, articulating sclerite; *bb*, base of bulb; *bp*, basiphallus; *df*, double-funnel of bulb; *dp*, distiphallus; *fp*, fork plate (*Gabelplatte*) of hypandrium; *g*, gonostylus; *pl*, posterolateral extension of basiphallus (internally micropubescent); *vl*, ventral lobe of distiphallus.





Figures 37–39. *Pentachaeta kirkspriggsi*, Wentworth Falls (37) left surstylus, outer surface view; scale 0.1 mm; (38) pair of cerci, left lateroventral view; scale = 0.1 mm. *Pentachaeta kirkspriggsi*, Mooney Mooney Creek (39) left gonostylus, subepandrial process, and associated parts; scale = 0.05 mm. *as*, articulating sclerite; *g*, gonostylus; *pl*, posterolateral extension of basiphallus; *sp*, subepandrial process.

Forest, near Lismore, Feb. 1965, D.K.M. (AM); 1♂, Iluka Rain Forest Reserve, Feb. 1965, D.K.M., R.L. (AM); 2♀♀, Mooney Mooney Creek, near Gosford, Dec. 1976, 1978, D.K.M. (AM); 4♂♂, 4♀♀, Springwood [probably vicinity of Sassafras Gully], Jan. 1956, D.K.M. (AM).

Other material examined. Queensland: Eungella National Park (near Broken River) (AM); Olmara Hills, near Dalrymple Heights (or Eungella), c. 1000 m (AM, QM); Crediton, near Eungella (AM); Finch Hatton, 180 m (AM); Finch Hatton Gorge (AM); 13 km and 17 km S of Ravenshoe (AM); Edge Hill, near Cairns (AM); Kuranda (AM); Paluma (AM); Austral Forest, near Bulburin, Monto district (AM).

### Description (male, female)

Resembling *P. kirkspriggsi* in most characters; agreeing with description of that species, except as indicated below.

**Coloration.** Antenna tawny-yellow as in *P. kirkspriggsi* (type colour form), or with segments 2 and 3 quite black (dark tropical colour form); palpus tawny yellow with c. distal quarter grey brown (darker in fresh specimens), black in dark tropical form. Fore tibia entirely tawny-yellow (type colour form) or with brownish apical zone (dark tropical form).

**Thorax.** Tibiae as in *P. kirkspriggsi*.

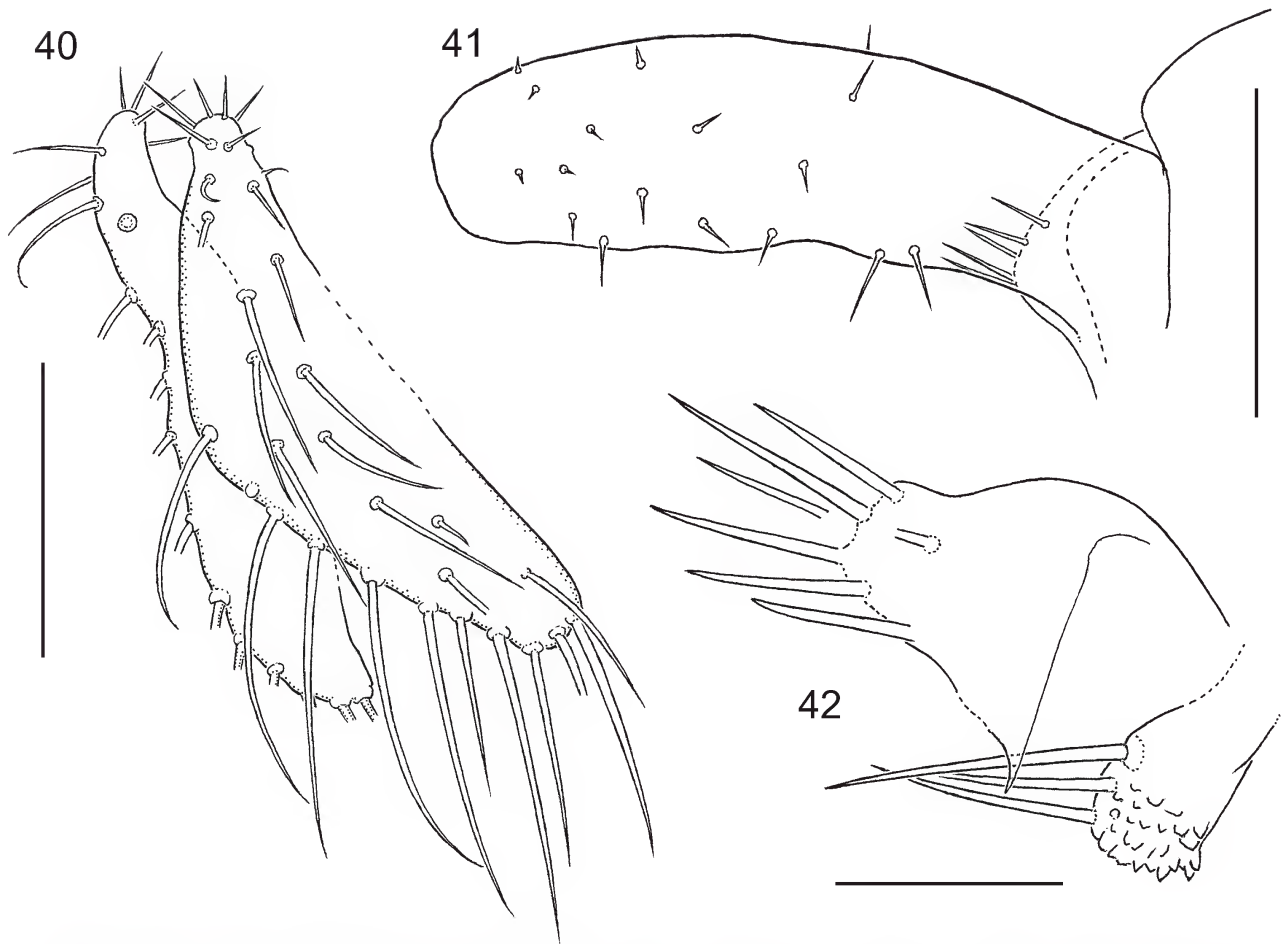
**Abdomen** (male) resembling that of *P. kirkspriggsi* except as indicated. Surstylus often slightly more slender than in *P. kirkspriggsi* with smaller setulae; subepandrial process slightly narrower distally than in *P. kirkspriggsi*, but somewhat variable (Fig. 42); gonostylus with posterodistal group of prominent tubercles and one to three large setulae; cercus slightly variable in shape but differing from that of *P. kirkspriggsi* in having anterior lobe tapered, not markedly produced and compressed, but slightly variable in shape.

**Dimensions.** Total length, ♂ 2.3–3.2 mm, ♀ 2.2–3.1 mm; length of thorax, ♂ 1.3–1.5 mm, ♀ 1.3–1.6 mm; length of wing, ♂ 3.0–3.3 mm, ♀ 3.0–3.6 mm.

**Distribution.** Eastern New South Wales: coastal districts and Blue Mountains; Queensland: Monto district in south of state (type colour form), sub-coastal ranges in tropics, from Kuranda to Clarke (Eungella) Range (mainly dark colour form). Map reference 7F, 7J, 7K, 8H (Fig. 4).

### Notes

*Pentachaeta pinguis* differs from other species of the genus except *P. impar* in having the palpus conspicuously darkened apically, but differs from that species in lacking



Figures 40–42. *Pentachaeta pinguis*, Royal National Park (40) pair of cerci, left lateroventral view; scale = 0.1 mm. *Pentachaeta pinguis*, near Springwood (41) left surstylus, outer view, with basal prominence seen through transparency; scale = 0.1 mm; (42) left gonostylus and subepandrial process; scale = 0.05 mm.

the brown zone on the upper margin of the sternopleuron. Males resemble those of *P. kirkspriigsi* and *P. physopus* in having *all* tibiae conspicuously thickened but differ in the shape of the cercus (compare Figs 41, 44), whereas the male of *P. impar* has only the hind tibia thickened and, again, a differently shaped cercus (compare Figs 40, 35).

Tropical populations of *P. pinguis* differ from all other *Pentachaeta* forms in having antennal segments 2 and 3 black. This is such a striking feature that I initially assumed these populations to represent a distinct species, but comparison of numerous specimens from both tropical and southern populations reveals no identifiable differences except in coloration. There is slight variation in the shape of the surstylus and cercus in both these populations, but the male cercus is consistently distinct from that of *P. kirkspriigsi*, and both surstylus and cercus are sharply different from those of *P. physopus*.

One male specimen of *P. pinguis* from within its tropical habitat (Eungella National Park) shows tawny-yellow antennae, but was preserved in alcohol before drying and mounting. It shows some bleaching of pigmented cuticle, and it is uncertain if this treatment fully explains the antennal coloration.

The specific epithet is a Latin adjective, obese or fat, in reference to the thickened male tibiae.

### *Pentachaeta physopus* McAlpine

Figs 43, 44

*Pentachaeta physopus* McAlpine 1985: 213–215, figs 18–23.

**Type material.** Holotype ♂. New South Wales: Mooney Mooney Creek, near Gosford [c. 33°26'S 151°15'E], 20.xi.1975, D.K.M. (AM K72569). Paratypes. See McAlpine (1985).

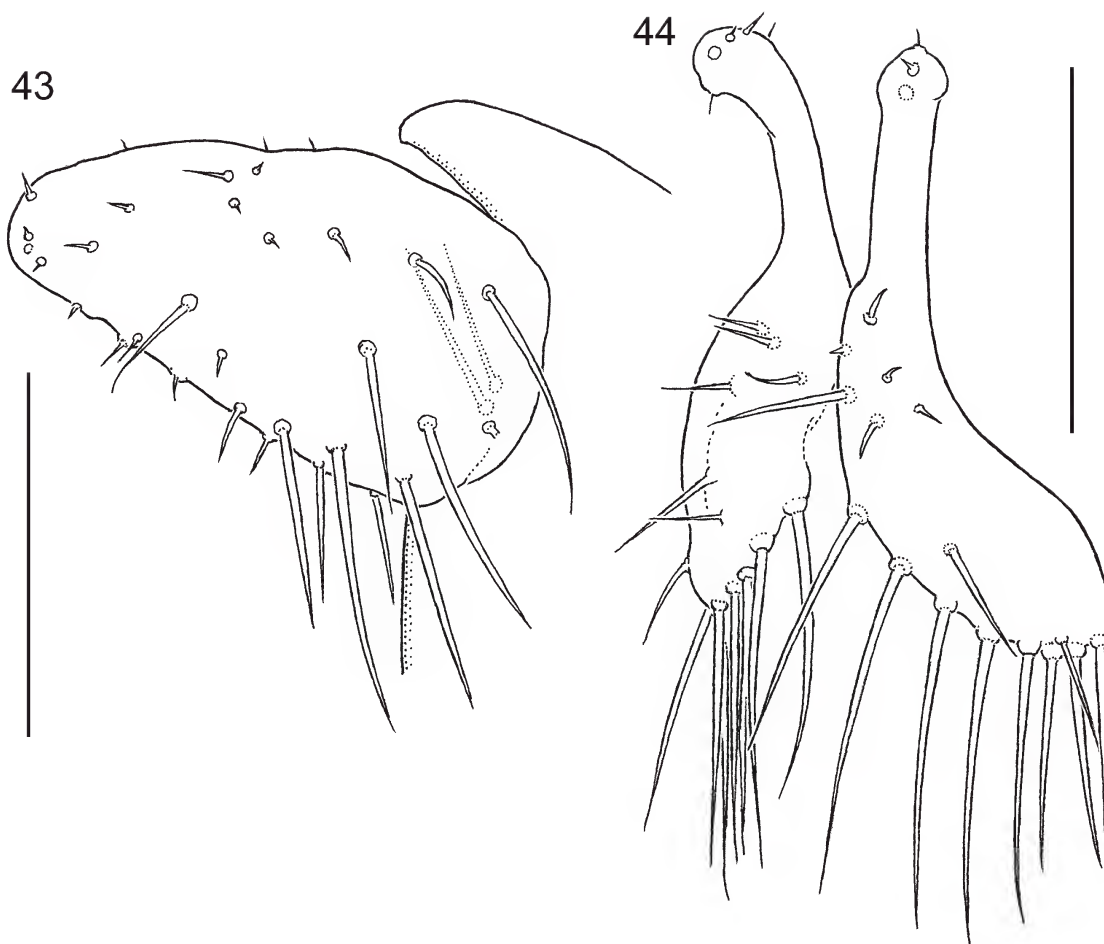
### Description

See McAlpine (1985).

**Distribution.** New South Wales: coastal and subcoastal districts from Allyn River to Nelligan district; also Blue Mountains.

### Notes

Among the species with all tibiae much thickened in that sex, males can be distinguished by having the palpus entirely pale yellow and fore tarsus entirely dark brown to black. The form of the surstylus and cercus (Figs 43, 44) is very different from that of related species. Females differ from those of all other species of the genus in their entirely dark fore tibia and tarsus, and from those of some related species in the entirely pale palpus (clean, non-greasy specimens).



Figures 43, 44. *Pentachaeta physopus*, Mooney Mooney Creek (43) left surstylus, outer surface view; (44) pair of cerci, left lateroventral view. Scale for both figs = 0.1 mm.

ACKNOWLEDGMENTS. I am indebted to John C. Martin for the photograph of *Pentachaeta pinguis*. Helen M. Smith critically treated the manuscript and arranged the illustrations. Names of collectors appear in the introduction.

### References

- Gill, G. D., and B. V. Peterson. 1987. 89. Heleomyzidae. In *Manual of Nearctic Diptera*, ed. J. F. McAlpine, 2: 973–980. Hull, Quebec: Canadian Government Publishing Centre.
- Gillies, William. circa 1909. *First studies in insect life in Australasia* (edition 2): 178 pp. Melbourne and Sydney: Whitcombe & Tombs.
- Gorodkov, K. B. 1963. On the fauna of Heleomyzidae (Diptera) in the Kamchatkan region. *Fauna of the Kamchatkan region*: 82–105. Moscow and Leningrad: Academy of Science, USSR. In Russian.
- Griffiths, G. C. D. 1972. *The phylogenetic classification of the Diptera Cyclorrhapha with special reference to the structure of the male postabdomen*. 340 pp. The Hague: W. Junk.
- Malloch, J. R. 1933. Acalyprata (Heleomyzidae, Trypetidae, Sciomyzidae, Sapromyzidae, etc.). *Diptera of Patagonia and South Chile* 6: 177–391, pl. 2–6.
- McAlpine, D. K. 1967. The Australian species of *Diplogeomyza* and allied genera (Diptera, Heleomyzidae). *Proceedings of the Linnean Society of New South Wales* 92: 74–106.
- McAlpine, D. K. 1985. The Australian genera of Heleomyzidae (Diptera: Schizophora) and a reclassification of the family into tribes. *Records of the Australian Museum* 36(5): 203–251. <http://dx.doi.org/10.3853/jl.0067-1975.36.1985.346>
- McAlpine, D. K. 2007. Review of the Borboroidini or wombat flies (Diptera: Heteromyzidae), with reconsideration of the status of families Heleomyzidae and Sphaeroceridae, and descriptions of femoral gland-baskets. *Records of the Australian Museum* 59(3): 143–219. <http://dx.doi.org/10.3853/jl.0067-1975.59.2007.1487>
- McAlpine, D. K. 2012. Notes and descriptions of Australian Helosciomyzidae or comb-winged flies (Diptera: Schizophora). *Records of the Australian Museum* 64(1): 51–70. <http://dx.doi.org/10.3853/jl.0067-1975.64.2012.1582>

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## A New Species of *Tamasa* Distant from an Unusual Cave-like Habitat in Australia (Cicadidae: Cicadinae: Tamasini)

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**ABSTRACT.** *Tamasa caverna* n. sp. is described from Black Mountain, northern Queensland, a mountain consisting almost entirely of large rock boulders. The species appears to be unique amongst Cicadidae in that the males sing from under these large boulders far from trees. Notes on its song and behaviour are provided.

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### Introduction

The genus *Tamasa* Distant has recently been redefined and its distinguishing features summarized (Moulds 1990, 2012); it includes four species endemic to eastern Australia. The new species described here is known only from Black Mountain, northern Queensland, and is unique amongst the Cicadidae because the males sing from under giant boulders far from trees. The song of this new species is analyzed and its habit of singing amongst the boulders discussed.

Terminology for morphological features and higher classification follow those of Moulds (2005). The following abbreviations have been used for collections housing specimens: *AM*, Australian Museum, Sydney; *JO*, Collection of John Olive, Malanda; *LWP*, collection of L. W. Popple, Brisbane; *MSM*, collection of M. S. Moulds, Kuranda; *QM*, Queensland Museum, Brisbane.

### Family Cicadidae Tribe Tamasini

#### *Tamasa caverna* n. sp.

Figs 4–10

**Types.** Holotype male, 12.i.2003, Black Mountain near Cooktown, Nth QLD, J. Olive (QM). Paratypes as follows, all from Queensland: 1♂, Black Mountain near Cooktown, 12.i.2003, J. Olive (AM); 1♂, Black Mountain near Cooktown, 12.i.2003, J. Olive; 1♂ 1♀, Black Mountain, 15°39'06"S 145°12'55"E 11, 11.i.2004, J. C. Olive; 3♂♂, Black Mountain near Cooktown, 23.i.2014, J. Olive & S. Orr; 1♂, Black Mountain near Cooktown, 24.i.2014, J. Olive (JO). 1♂ (genitalia prep. T79), Black Mountain, south of Cooktown, 15°39.1'S 145°13.2'E, 11.i.2004, J. Olive; 1♂, 1♀ (female specimen no. 04.QLD.STO.11, voucher for molecular sample), Black Mountain, S of Cooktown, 15°39.1'S 145°13.2'E, 12.i.2004, Cooley, Hill, Marshall, Moulds (MSM). 1♂, Black Mountain via Cooktown, 4.i.2001, R. Morgan (LWP).

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Figure 1. Black Mountain, the habitat of singing males. The males sing below the rocks where it is shaded and cool. Photo by Kathy Hill.



Figure 2. Aerial view of Black Mountain (mountain at left). Photo by Fanie Venter.





Figure 3. Close up of the large boulders of Black Mountain inhabited by *Tamasa caverna* n. sp. Photo by Fanie Venter.

### Description

*Male.* Figs 4, 6–9.

*Head* brown; central area around ocelli black and not reaching posterior margin; area adjacent to epicranial suture brown; a dark brown triangular mark situated about midway between lateral ocellus and lateral cranial depression; a transverse black mark extends from anterior cranial depression almost to eye but reaching eye in some specimens; a further black mark from anterior cranial depression to supra antennal plate; supra antennal plate brown, black centrally; cranial depressions brown; a black line adjacent to eye ventrally; ocelli yellow to reddish amber; postclypeus brown with transverse grooves dark brown to

black, moderately covered with silvery-white cilia; a well-defined broad brown fascia ventrally at midline narrowing toward centre of its length; lorum brown, broad dark brown to black mark adjacent to postclypeus; anteclypeus brown with dark brown midline and black distally; rostrum usually reaching well beyond distal margin of hind coxae but just reaching in some specimens, light brown with a dark brown fascia ventrally at midline, darker brown or black apically; antennae dark brown to black.

*Thorax.* Pronotum light brown with a black mark either side of midline extending from anterior margin to pronotal collar, these broader anteriorly and always joined at pronotal collar and sometimes at anterior margin; a broad brown fascia on midline, broader anteriorly, area between lateral



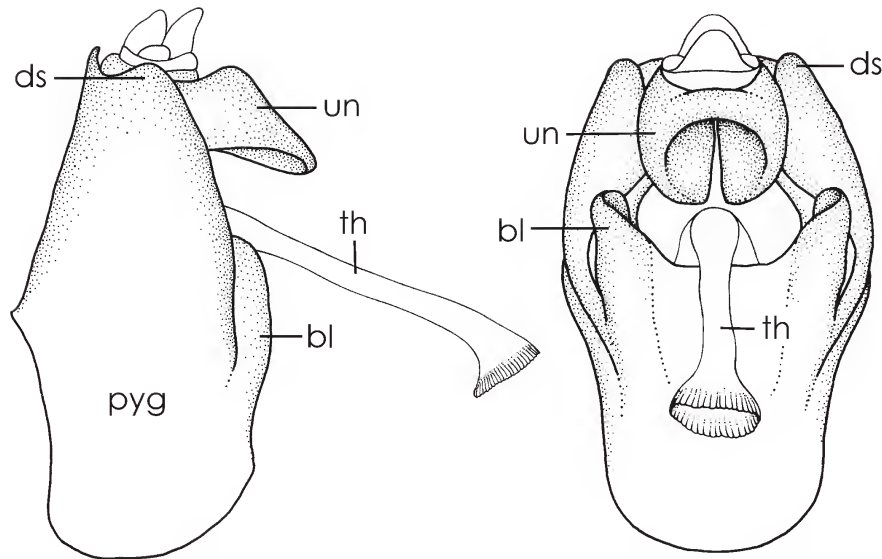


Figures 4–7. *Tamasa caverna* n. sp. (4) male, dorsal view; (5) female dorsal view; (6) male body ventral view showing opercula; (7) male timbal and timbal cover.

fissure and pronotal collar with black mark anteriorly and a dark brown mark posteriorly; area between lateral and paramedian fissures with black mark anteriorly and a dark brown lineal mark somewhat parallel to midline posteriorly; pronotal collar light brown to cream with anterior margin black. Mesonotum brown; submedian sigilla well defined with broad black inner margin and a thin black line along parapsidal suture; scutal depressions dark brown or black; a dark brown or black fascia at midline extending anteriorly from between scutal depressions, often tapering anteriorly and sometimes expanding laterally between the scutal depressions; lateral sigilla not clearly defined with variable amount of dark pigmentation but always with dark brown or black patch adjacent to pronotal collar and at apex; arms of cruciform elevation brown.

*Legs* brown, fore femora with a broad brown or black linear fascia dorsally, extending almost to distal margin where it curves downward on the outer side to terminate more or less hook-like; inner side of fore femora with a dark brown fascia extending full length and extending to each femoral spur; femoral spurs black; fore coxae with a broad black fascia along midline and a black patch distally on the inside; mid and hind coxae with a black patch distally on the outer side.

*Opercula* (Fig. 6) light brown to cream with margins black and distomedial area usually dark brown or black; moderately covered with silvery-white cilia; usually widely separated but meeting or nearly so in some specimens; lateral and distal margins evenly curved forming a semi-circle; medial margin straight.



Figures 8–9. *Tamasa caverna* n. sp., male genitalia. (8) lateral view; (9) ventral view. *bl* basal lobe, *ds* distal shoulder, *pyg* pygofer, *th* theca, *un* uncus.

*Wings* hyaline; costal vein light brown to node; subcostal and radius anterior veins dark brown; veins forming cubital and ulnar cells light brown; median veins and cubitus anterior veins dark brown; ambient vein and veins forming bases of apical cells 1–5 and 7 dark brown; sometimes weakly tinted at distal ends of apical cells 1–4; infuscated at cross veins r and r-m; basal membrane grey; basal cell opaque to lightly translucent brown sometimes becoming hyaline distally. Hind wings hyaline; veins dark brown; jugum infuscated basally but remainder of anal lobe hyaline.

*Abdomen* brown; moderately covered with silvery white cilia; tergite 1 light brown; tergite 2 light brown, the timbal covers weakly developed, broadly triangular with anterior margins black and curled upward; tergite 3 with narrow dark brown or black anterior margin becoming broader laterally; tergites 4 to 7 usually with some dark coloration along anterior margin but absent in some specimens; tergite 8 with a broad dark brown or black patch either side of midline adjacent to anterior margin. Sternites black, light yellow-brown along posterior margins of sternites 1–6, sternite 7 entirely black, sternite 8 light brown with black fascia along midline.

*Timbals* (Fig. 7) with five ribs; ribs 1–3 long and of similar length, ribs 4 and 5 shorter with rib 5 shortest; ribs 1 and 2 always joined dorsally, the lower half of ribs 1 to 4 broader, rib 5 thin for its entire length.

*Female* (Fig. 5). Similar to male. Abdominal segment 8 light brown on its lower half and black on its upper half. Ovipositor brown, black apically; ovipositor sheath not reaching beyond anal styles and dorsal beak.

**Measurements.** The range and mean (in mm) for all available specimens (9♂♂ and 2♀♀).—Body length, male 23–26.5 (23.83), female 24.0–24.4 (24.2); forewing length, male 32–36 (34.05), female 34.6–35 (34.8); head width, male 8–9 (8.49), female 8.5–8.9 (8.7); pronotum width, male 8.5–10 (9.09), female 9.3–9.5 (9.4); abdomen width, male 9–10 (9.61), female 9.4–9.5 (9.45).

**Distinguishing features.** *Tamasa caverna* n. sp. is most similar to *T. doddi* (Goding & Froggatt, 1904) and *T. burgessi* (Distant, 1905) but is easily distinguished from those two species in lacking infuscation at the tips of the fore wings.

The male genitalia of *T. caverna* appear to be unique in having an uncus that is substantially tubular and in lateral view tapers to a bluntly rounded apex and a theca that is straight for most of its length with a trumpet-like apex very finely fluted around its rim.

**Etymology.** Named from the Latin *caverna* meaning a cave, grotto or cavern and referring to the cavern-like habitat of the singing males.

### Distribution and habitat

Known only from Black Mountain south of Cooktown in northern Queensland (Figs 1–3) where males are found amongst large granite boulders. The males rest and sing from within caverns between boulders, usually clinging to the undersides of boulders. The possibility that adults also occur in adjacent rainforest areas away from boulders has not been excluded. The distribution of this species may extend to similar granitic boulder screes in the Melville and Bathurst Ranges north of Cooktown. There are records only for January but based on emergence cycles of other species adults might be encountered throughout much of summer wet season, December to February and possibly beyond.

### Song

The song consists of a broken revving sound often followed by a continuous, mildly rattle-like, call (Fig. 10). The revving component of the song comprises short revving sounds at about one second intervals which may last the entire song. On other occasions there is a continuous or uninterrupted finale. Although singing can occur throughout the day, songs with a continuous part are more often heard in late afternoon and at dusk, this part of the song being similar to all other *Tamasa* species. The frequency of the call is concentrated between 4 and 8 kHz.



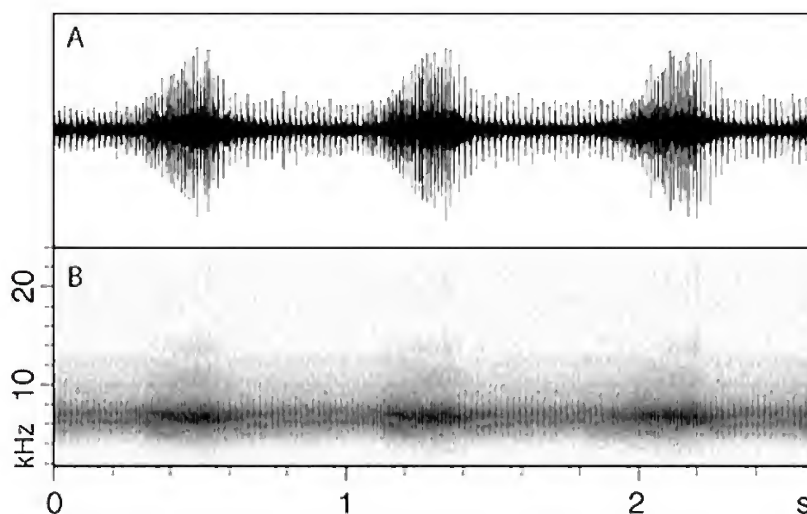


Figure 10. *Tamasa caverna* n. sp., oscillogram (A) and sonogram (B) showing three-second fragment of revving song component, specimen number 04.AU.QL.STO.10. Sound energy (mainly background noise) below 2 kHz was removed before illustration. The recording was made on a Sony TCD-D8 digital recorder sampling at 48 kHz, with a Sennheiser ME62 condenser microphone powered by a Sennheiser K6 power module using battery power and a Sony PBR-330 parabolic reflector. The sonogram and oscillogram were generated in Raven Pro 1.4 build 48, with default settings plus a Hann window set to 256 samples and a 3 dB filter bandwidth of 270 Hz. The recording was made on 11 January 2004 at Black Mountain, south of Cooktown. The ambient air temperature at the road during the recording was 31.5°C; temperatures among the rocks were cooler.

The reason why males call from under boulders remains unknown, no study has directly addressed this question. Dr David Marshall, who has recorded the song, suggests that one explanation may relate to optimization of microclimate, especially in regard to shade and temperature. The species of *Tamasa* are mesic-adapted, with most, especially *T. doddi* and *T. burgessi*, preferring singing stations in forest interiors where microhabitats are shaded and cooler. Similarly, during periods of intense summer solar radiation when exposed and dark-coloured boulders undergo extreme heating, we believe males are driven to cooler interior rock faces—a tropism to shaded and cooler microclimates typical of other *Tamasa* species.

Exposed rock surfaces become superheated to levels that even effect overhanging tree branches making them also unsuitable as singing stations. By locating under rocks and in deep fissures between boulders singing males can prolong their calling periods when otherwise they would cease activity to avoid overheating. The degree to which this behaviour is temperature dependent could be tested on cloudy but warm days—males and females may be more willing to sing and rest on upper rock surfaces, or even in nearby branches. There is also the separate question of colour-pattern matching and the habit of resting on rock surfaces of corresponding colour.

We cannot dismiss the possibility that singing among rocks and boulders has adaptive significance for this species and has become the sound environment in which auditory communication between the sexes must occur. We think this less likely because moving from branches to between and under rocks would reduce intensity, directionality and distance of calls and thereby be subjected to negative selection. Nevertheless, there may be an acoustic modification that occurs within the boulder “galleries” that has become an important part of this species’ calling and mating behaviour.

The Black Mountain Boulder Frog, *Cophixalus saxatilis* Zweifel & Parker also inhabits rock grottoes of Black Mountain (Zweifel & Parker, 1977), but it occurs in other environments away from the boulders. Since the frog calls in both situations it apparently attains no particular acoustic advantage by calling from under and between rocks. Rather it occupies rocky habitats in response to a preference for damp and cool.

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## References

- Moulds, M. S. 1990. *Australian Cicadas*. Kensington: New South Wales University Press. 217 pp, 24 pls.
- Moulds, M. S. 2005. An appraisal of the higher classification of cicadas (Hemiptera: Cicadoidea) with special reference to the Australian fauna. *Records of the Australian Museum* 57(3): 375–446.  
<http://dx.doi.org/10.3853/j.0067-1975.57.2005.1447>
- Moulds, M. S. 2012. A review of the genera of Australian cicadas (Hemiptera: Cicadoidea). *Zootaxa* 3287: 1–262.  
<http://www.mapress.com/zootaxa/2012/zt03287p262.pdf>
- Zweifel, R. G., and F. Parker. 1977. A new species of frog from Australia (Microhylidae, *Cophixalus*). *American Museum Novitates* 2614: 1–10.

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